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EDITORIALS

"Food and Fractions"

Just a year ago, on the editorial page of AGRICULTURAL ENGINEERING for January 1941, appeared an editorial, over the name of Walter B. Jones, with the above heading. That editorial is being reprinted in this issue because it has perhaps even greater significance today than it had then; and also because it puts the finger, though not in so many words, on the exceedingly vital role which the agricultural engineering profession and the producers of farm machinery and other equipment of all kinds, are in best position to play in America's all-out war effort.—EDITOR.

FOR all that has been said about America's unpreparedness, no nation on earth is so well fitted for a fight to the finish.

We may not be ready for a blitzkrieg. No doubt we need thousands of planes and tanks, and the training of millions of men. But no country in the world is so well able to produce the machines and munitions of defense, so well able to spare the man-power for their possible use.

Why? Because war in the ultimate is a fight with food and fractions.

Not only do armies fight on their stomachs, as noted by Napoleon, but the nations behind them must be fed too—and well fed if national morale is to be maintained. America has the acreage and the fertility of farm land to feed soldier and civilian alike all they can eat, and still have a staggering surplus for the wastes and destruction of war.

But what about the fractions?

The nation best prepared for war is the nation which can grow its food with the smallest fraction of its man-power. Only the remaining fraction, the men not needed for growing crops and feeding livestock, can take time off to train for army and navy and air corps, to build bombers and make bullets.

Of all great nations, America grows its groceries with the smallest fraction. Only 100 years ago it took 75 per cent of our people on the farm to grow enough extra to feed (and clothe) themselves and the other 25 per cent. Three could feed four. Now the fractions are reversed. Only 25 per cent of our population is on the farm. It takes only one to feed four. The other three are engaged in creating the comforts and luxuries which we call the American standard of living. If the need comes, at least one of the three can stop fashioning fur coats and finger a trigger.

Why have we been able to whittle down the food-growing fraction to one-fourth?

Not by soil fertility and yield-per-acre, for several of the nations now at each other's throats grow more grain and pasture more beef on an acre. Not by better farm animals, for our best breeds are borrowed from old-world regions whence come such names as Holstein, Guernsey, Angus, Hereford, Leghorn, Merino, Clydesdale.

No, the thing that enables the American farmer to grow such amazing amounts of food is something as distinctly American as baseball—farm machinery. America gave birth to the steel plow, the reaper, the self-binder, the tractor, the combine. No other nation has the skill or the will to use them so well. No other nation puts so much power under the hand of each plowman. None provides so great an investment in machinery for each man.

Because our farm mechanization is so great, our farm fraction so small, we can, if need be, mobilize more of our manpower for a total defense than any other great nation on the globe. Provided, of course, that the other three-fourths of our people can work with a will and an effectiveness anything like that already exercised by the men of agriculture.

The battle of France showed the mastery of machines in offense. The battle of America, if it ever comes, will show the mastery of machines in defense. Foremost among these machines will be those of the farm. And foremost among our preparations to prevent the battle of America must be more, not less, machinery for our farmers.

Our Job Now

AS ONE group in the national scheme of things, just where do agricultural engineers fit into the nation's war program? For more than a year a steady stream of our colleagues has joined the various branches of the armed services, and this will continue. We are proud of these men, and we honor them for fulfilling a paramount patriotic duty in America's all-out participation in a world-wide war.

But the job of those on the "home front" is likewise a most important one. Whether they are serving with industries that furnish the implements and equipment of agriculture, with colleges of agriculture and experiment stations, with various agencies of the federal government, or in a variety of other capacities—these agricultural engineers are concerned primarily with farm production for food, clothing, and other materials so essential to the war effort.

As we proceed step by step into the future, new demands for service created by the exigencies of the hour will unfold, and agricultural engineers will welcome such opportunities to contribute to the best of their abilities toward the common goal. Probably the most important thing before them just now is the big problem facing agriculture, namely, the need of greatly increasing production but with a diminishing supply of men, machinery, and materials. The challenge of this situation is a real one, and agricultural engineers are in position to furnish a large measure of the help that is needed.

Under leadership of the federal and state agricultural extension services, and with the generous cooperation of the farm equipment industry, a nation-wide effort is taking form to offset to some extent the serious shortages of new equipment that will be increasingly felt in the months to come. The purpose of this program is to encourage and assist farmers in plans for the wide-scale repair of equipment now on farms, where such repair is justified from the standpoint of both economics and efficiency, and for maintaining the farm production plant as a whole at the highest possible level of effectiveness in the face of what is admittedly a very difficult situation.

While considerable progress has already been made to convert the nation's manufacturing industries to wartime production, it is hardly more than a beginning compared with what is contemplated under the all-out war effort that is expected will get under way rapidly. This will bring about many changes in the existing order of things, many new and perplexing problems, and involve not a little sacrifice on the part of all. Therefore, as the months pass, agricultural engineers will be required to meet many new situations and needs as they develop. This they will do courageously and with credit to themselves and to the profession. So whether on the battle front or on the home front, our group will be chiefly concerned for an indefinite time in how best it can help to carry on the world crusade for the preservation and maintenance of freedom to a satisfactory conclusion. The reward of which we all feel assured will result from the struggle now engaging nearly all of mankind, inspires us and spurs us on to do our part faithfully and cheerfully. Just now, however, we are going to buckle down and do the main job of the hour, and when that is finished we will be ready to go forward to happier tasks and larger achievements.

AGRICULTURAL ENGINEERING

VOL. 23 JANUARY 1942 NO. 1

Tractor Stop-Hitches

By A. W. Clyde

FELLOW A.S.A.E.

THE PROBLEM of plowing fields containing stones or roots has apparently not been solved to the farmers' satisfaction. At least, it can hardly be considered solved until many of them use devices which reduce breakage and delay. The ordinary release hitch gives protection against breakage up to three bottoms, if steel shares are used. Lost time in recoupling has increased as speeds have gone up and as air tires have come into common use. The cost of more satisfactory protective devices is often mentioned as preventing their adoption, but since cost is subject to change, this need not always be a deterrent to a worthwhile improvement.

This paper is limited to a discussion of the general method of stopping the plow and tractor when an obstruction is hit. The ideal type of protection is probably relief for each plow bottom, similar to spring trips for cultivator shovels. Stump-jump plows used in other countries are an example of this. Such devices can be made to return the plow to working position after it has passed an obstruction, thereby eliminating a stop. It would seem not to be difficult to apply this to a single-mounted plow, but on multibottom separate plows the use of this method entails considerable change in design.

The question is sometimes asked, "Why isn't farm machinery made strong enough so it will not be broken by hitting a stone or a root?" The answer is that the cost would be prohibitive, even if we assume it could be built. Gun makers long ago learned the hopelessness of trying to mount guns rigidly. If the gun is allowed to recoil or move back when fired, the force of reaction can be kept down to a reasonable value. It is noteworthy that the recoil mechanism of a 37-mm anti-tank gun has to handle the same amount of energy as is needed to stop a 3000-lb tractor traveling at 3.3 mph (miles per hour). At this speed the tractor has about 14,400 in-lb of kinetic energy. If it stopped in a distance on one inch, even though declutched, the average force required is 14,400 lb. It is evident from this that elasticity, rather than rigidity, is needed to cushion the shock and reduce the force. Appreciable stopping distance is vital if the implement is not to be overstressed.

There is a tendency for people to think that a light tractor is not severe on a plow because the drivewheels can spin easily. It is true that in sudden stops a light tractor can do less damage than a heavy one. We have found by experience that light tractors bend plow beams in spite of limited traction. The worst offender is the kinetic energy of the tractor, not its maximum tractive effort; hence anything that does not control the kinetic energy is limited in usefulness.

The protective feature of the Ferguson system is unique. When the plow strikes a solid stone, the pull on the tractor is momentarily lowered near the ground. This, together with the fact that the center of gravity of the tractor is higher, reduces the load on the drivewheels and makes it easy for them to spin. It is unlikely, however, that this would give much protection unless there was elasticity in the hitch which allows the tractor to move ahead appreciably. In practice, we find that the combination of elasticity and reduced traction protects steel shares up to 3 mph, provided unusual weight has not been added. For cast iron shares the safe speed is considerably less than 3 mph. Since kinetic energy of the tractor is the main cause of damage, the most direct way to attack the problem is to provide stopping distance. Loss of traction is helpful but does not get at the root of the difficulty.

Efforts to develop practical stop-hitches started many

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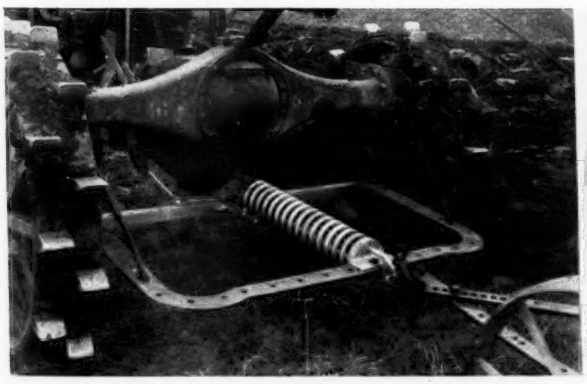


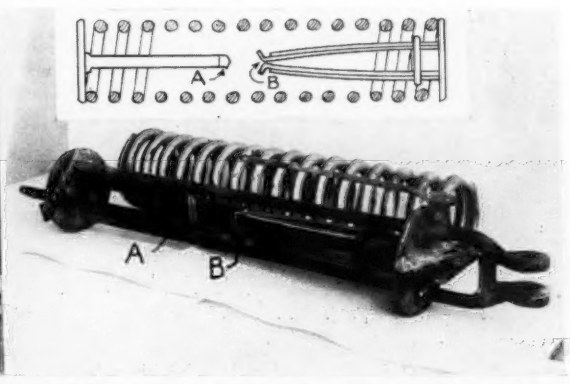
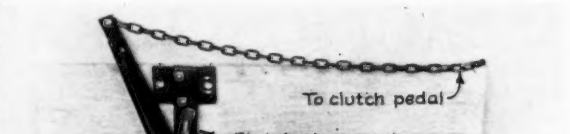


Fig. 1 (Left) In this model of stop-hitch the tractor is declutched when the spring is deflected 5 to 5½ in. An additional deflection of 5½ to 6 in is provided for stopping. Capacity, 17,000 in-lb • Fig. 2 (Right) A modification, providing a supplementary release, increases the capacity of the same model tractor stop-hitch to over 20,000 in-lb with the same spring as in Fig. 1

Fig. 3 (Left) A release is added in this stop-hitch to handle normal pull. The same spring as used in Figs. 1 and 2 now gives 22,000 in-lb capacity • Fig. 4 (Right) A commercially built stop-hitch that operates on the same principle as the one in Fig. 3



years ago. One farm machinery company has compiled a list of 43 patents on stopping a tractor by disengaging the clutch on overload or striking an obstruction. In spite of the large amount of work represented by these patents, few such devices are in use. Apparently the solution of the problem is not easy.

One of the early attempts along this line was the spring drawbar. It is now reappearing on some plows mounted on small tractors. Such springs are expected to cushion the shock by allowing the tractor a few inches of travel before it is stopped with the wheels spinning. They serve a useful purpose but are seldom adequate. Too often the tractor is not stopped when the limit of spring movement is reached. This causes impact on the plow which frequently does damage. In such cases the capacity of the spring (average force multiplied by distance) is not as great as the energy to be absorbed. In other cases the maximum spring force may be more than the plow can withstand.

Several types of more complete stop-hitches will be described because of their characteristics. Unless otherwise mentioned, all disengage the clutch when the stone is struck. Naturally the details of the clutch mechanisms are not the same, but all attempt to have the clutch immediately usable.

The first one to our knowledge was offered for sale about 13 years ago. It was apparently little used because of inadequate spring capacity. McKibben[1]* in 1930 built and tested one while working at this institution. The spring used had enough capacity for first gear but not for second gear. Lack of time prevented him from getting as large a spring as was desired. Soon after the International Harvester Company made a hitch which depended on rolling resistance to stop the tractor; it allowed the tractor to roll ahead 22 in after the release tripped. The driver then reset the clutch device and backed the tractor, the hitch being guided into place automatically. The author worked with it and reported[2] on the principles involved as well as on the possibility of adding springs to it. It usually worked well with steel wheels on fairly level ground, but was not well adapted to the lower rolling resistance of air tires. Six feet or more of stopping distance is needed on level ground with air tires, and, if a stone were struck while going down a slope of 5 to 6 per cent with firm footing, rolling resistance would never stop the tractor.

Experience with the stop-hitch just described, and the desire to have the tractor pulled back automatically, prompted us to build the hitch shown in Fig. 1. The spring was calculated for more than 3 mph on level ground, taking the normal drawbar pull and declutching the tractor when the pull exceeded a certain value. Spring deflection of $5\frac{1}{2}$ to 6 in then remained for stopping the tractor. Not satisfied with the constant movement of the spring in normal work, we modified it as shown in Fig. 2. When the spring deflected about $2\frac{1}{2}$ in, part A contacted springs B which were adjusted to hold until an overload occurred. This left more spring movement available for stopping the tractor, hence gave more capacity than Fig. 1. The next step was to add a complete release, as in Fig. 3, to relieve the spring entirely of the normal pull. Except for a small preload, this makes the entire capacity of the spring available for stopping the tractor. When used in this way, the spring shown is ample for heavier tractors or higher speeds than either Figs. 1 or 2. The trigger of the clutch throw-out is pulled by a cable in a conduit whenever the release trips. This form of stop-hitch has now been used four seasons.

Fig. 4 operates on the same principle as Fig. 3. It is now being sold in three sizes by the E.R.D. Manufacturing Company. Evidently by trial, this company has arrived at suitable spring capacity. The medium size which we have has capacity for a 4500-lb tractor going nearly 3 mph on level ground, 17,300 in-lb.

Devices like those referred to, which use a spring for stopping the tractor, have two characteristics which are not ideal, as follows:

1 The spring force varies from zero or some low value up to a maximum. The average is what counts and the permissible maximum is limited, hence a more nearly constant force would be preferable.

2 Most of the energy is merely stored in the spring instead of being dissipated. Some provision for releasing it from the spring without violence may be needed. For example, the counterrecoil of guns is controlled as well as the recoil.

Before taking up means of meeting these objections, certain factors of design need to be considered. Several attempts to make stop-hitches have been disappointing because of lack of knowledge of the amount of energy to be absorbed. This can be calculated for any conditions and provision made to handle it.

SYMBOLS

W = weight of tractor, pounds
K = kinetic energy due to rotation of wheels, inch-pounds
S = speed, miles per hour
d = stopping distance, inches
T = maximum tractive effort, pounds
f = slope of ground, feet per 100 ft
G = average total stopping force, pounds (Includes rolling resistance and braking resistance as well as main force from implement.)

*Superscript figures refer to the bibliography appended to this paper.

K is difficult to calculate exactly, but it can be approximated. From the formula for kinetic energy due to rotation, it can be shown that, if a wheel has no slip, each pound of weight concentrated at the rim contributes as much additional energy due to its rotation as it furnishes from its general forward movement. Thus, if 10 per cent of a tractor's weight is near the wheel rims, then K is about 10 per cent of the energy due to translation of W. Ten per cent is probably ample for air tires. Steel rims and lugs are usually from 8 to 15 per cent of a tractor's weight, while tracks are from 16 to 24 per cent. From the familiar $\frac{1}{2}\ mv^2$, the energy in inch-pounds due to translation can be converted into $0.4\,WS^2$. Two approximate formulas may be made, based on the principle that the work of stopping a tractor is equal to its kinetic energy $\pm$ any work due to other forces, as follows:

Tractor declutched at instant of hitting obstruction,

$$G = \frac{0.4\,WS^2}{d} + \frac{K}{d} \pm W\,\frac{f}{100}$$

(The quantity K/d cannot exceed T since wheels can spin when T is reached.)

Tractor not declutched,

$$G = \frac{0.4\,WS^2}{d} + T \pm W\,\frac{f}{100}$$

If brakes are used to furnish part of G, it should be remembered that they are limited as is T. In fact, the maximum stopping force from brakes would usually be less than T because of so-called weight transfer.

So far most of G has been furnished by the plow. It is therefore worth while to have some idea of what plows will stand. We have arrived at some values for this by the deflection of a spring, also by a method similar to the Brinell hardness test. In the latter method a pull of the plow is carried by a steel ball resting on a piece of copper. After the stone is struck, the diameter of the indentation is measured under a microscope and compared with the indentations caused by forces in a testing machine. By these methods it appears that solid steel shares can stand a force of about 5000 lb without damage. Chilled iron shares are highly variable, but most of them will stand 2500 lb. We use practically no soft center shares, hence have little information on their strength. We think they are not quite as resistant to impact as solid steel. It is important to notice that the above forces are measured away from the share. The actual force at the share is higher because the inertia of the plow itself is added.

The question may arise as to whether the weight of the plow should be included in computing kinetic energy. We think that is unnecessary, at least with one and two-bottom plows, because the figures on strength of shares given above include some allowance for the plow's energy and because some elasticity always exists in the plow hitch.

The disadvantages of springs have already been mentioned. Their failure to dissipate energy is annoying. In the stop-hitches described, the energy stored in the spring is usually more than is needed to pull the tractor back for recoupling. Violent recoupling is often the result. Gun makers have exactly the same problem; namely, that a certain amount of energy must be absorbed, and only enough retained to return the gun gently to firing position. Violent recoupling in a stop-hitch corresponds to uncontrolled counterrecoil in a gun.

Hydraulic cylinders, dash pots, or shock absorbers are excellent for dissipating energy. They convert the energy into heat by fluid friction. It is rather easy to regulate their resistance. For example, they can be made to give a constant resistance as the piston is stopped from some given initial velocity. They can also be made so that the combination of spring and cylinder will have a constant resistance.

To test the value of a hydraulic cylinder, one was built into the hitch shown in Fig. 5. In principle it is exactly the same as Figs. 3 and 4, except that the spring is lighter and is supplemented by the cylinder. The resistance of the latter was planned so that the combination gives a constant resistance. The spring and cylinder are similar to recoil mechanisms. Check valves in the piston are provided to facilitate recoupling. The performance of this combination has been very satisfactory, the stopping and recoupling being very smooth. The constant resistance permits fair protection of cast shares on one and two-bottom plows without extreme stopping distance.

All of the foregoing stop-hitches have a clutch throw-out. This serves a useful function but adds to the cost and to manufacturing difficulties, since it must be modified for different tractors. For these reasons, we decided to experiment with a device which would stop the tractor even with the drivewheels spinning. This seemed possible with air tires where the margin of traction in plowing is usually small. Since the maximum tractive effort of a two-plow tractor might be about 2500 lb, this method offered hope of protecting steel shares, but practically no hope of protecting cast iron shares. Fig. 6 shows a hitch of this kind. A release carries the normal pull. After it trips, the tractor is allowed 12 in of forward movement. The operator declutches as soon as possible and then backs up for recoupling. A check valve in the piston reduces resistance on the return. In the two-plow size we tried to design for a constant force of 5000 lb, with a 4400-lb tractor having an

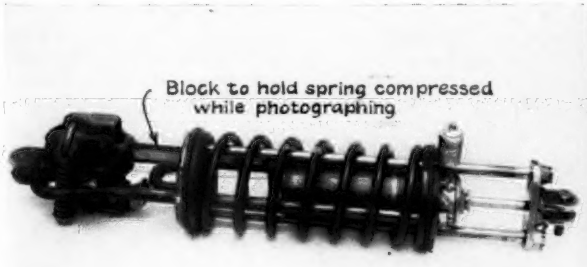


Fig. 5 (Left) A new stop-hitch with cylinder for helping spring and preventing violent recoupling • Fig. 6 (Right) A simple hydraulic stop-hitch in extended position. This model has no spring and no clutch throw-out

initial speed of 3.2 mph on level ground. Two of these have been tested with encouraging results.

This application of hydraulic cylinders is believed to be new. For this reason, a discussion of principles is in order. Information on gun recoil principles and designing can be found in Hayes'[3] textbook.

The area of orifice may be calculated from the formula,

$$a = \frac{.0104v}{C}\sqrt{\frac{wA^3}{R}}$$

derived from the formula for velocity of flow through an orifice, $V = C\sqrt{2gh}$, as follows:

$$Va = vA \quad \text{or} \quad a = \frac{vA}{V} = \frac{vA}{C\sqrt{2gh}}$$

$$R = \frac{hwA}{144} \quad \text{or} \quad h = \frac{144R}{wA}$$

Hence $$a = \frac{vA}{C\sqrt{\frac{(2g)(144R)}{wA}}} = \frac{.0104v}{C}\sqrt{\frac{wA^3}{R}}$$

a = area of orifice or orifices, sq in
w = weight per cubic foot of fluid
A = effective area of piston, sq in
v = velocity of piston at any point, fps
R = resistance for any selected value of v, pounds
C = orifice coefficient.

The value of C must be determined experimentally for various shapes and sizes of orifices. So far we have assumed it as 0.6, but expect to check on that value. If C is a constant in any particular case, and a constant R is desired, the size of the orifice varies directly with v. However, v does not decrease uniformly as the tractor stops. Fig. 7 shows how v will change as a tractor is stopped with a constant R which gives uniform deceleration. This is arrived at by the relations of velocity, distance, and time with uniform acceleration or deceleration. By replacing time with the proper value of distance, it will be seen that distance is proportional to the square of the velocity. The curve merely puts this relationship in a more usable form for our purpose. For example, when the tractor has gone 50 per cent of d, its velocity is over 70 per cent of the initial velocity. This curve is a parabola. It also shows the throttling bar method used much in gun recoil mechanisms to reduce the size of orifice as the velocity of the piston decreases. Another method of getting the same result is to use the clearance between the piston and cylinder as the orifice, the cylinder bore being varied as desired. We have used both of these methods. The throttling bar curve will be practically a parabola for a constant R in the hydraulic cylinder. If, however, a constant total force is desired from a cylinder and spring combined, the curve will be different. In either case the size of orifice can be computed for several points over the stopping distance. With a direct-acting device as in Fig. 6, the initial value of v is the speed of the tractor expressed in feet per second.

An unexpected feature appeared in the design of this device. We usually assume that if a stop-hitch is ample for a certain speed, it is more than ample for any lower speed. This is usually true for stop-hitches having a clutch throw-out, but may not be true for the type under consideration. The reasons for this are that its resistance is proportional to v^2 or to S^2, and that its resistance should always be

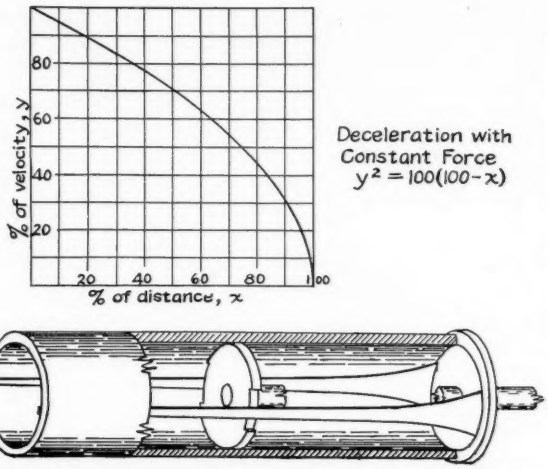


Fig. 7 The top view shows the relation of velocity and distance in uniform deceleration, while the bottom view shows the throttling bar method of regulating size of orifice

greater than T. Suppose it is designed for 5000-lb resistance at 3.2 mph. If the speed of the tractor is less, then the resistance is less. At some lower speed, the resistance will become only equal to or less than T with nothing to take care of the kinetic energy. Evidently the design must be a compromise between a high and a low speed. Unless the engine stalls, such a hitch will always extend its full distance. We have provided rubber bumpers to help reduce shock near the end of travel. The rubber bumpers and the other features of design seem to be on the side of safety because we have not damaged any plows with steel shares. We had little hope of protecting cast iron shares. We have, however, hit several stones with cast shares and were surprised that the only breakage was on the first test with a hitch from which the oil had been omitted.

The advantage of a clutch throw-out may be shown by comparing a hitch like Fig. 6 with and without the throw-out. This hitch was planned for a 4400-lb, air-tired tractor traveling at a speed of 3.2 mph and a resistance of 5000 lb. By adding a clutch throw-out, the resistance could be reduced to about 2500 lb, and the distance reduced from 12 to 8 in. This is a distinct benefit. The clutch throw-out was omitted only for simplicity and lower cost.

We have only a little knowledge as to the best fluid to use. Probably it should be one with minimum viscosity change from about 32 to 90 F. So far 10W motor oil has been used. Viscosity tests on it, also on a shock absorber fluid and on a brake fluid, indicate that the motor oil is about as good as the others in this respect.

We hope that from some of the devices described or from other possibilities, someone will be able to develop a mechanism which will be reasonably satisfactory and which can be sold for an attractive price. It remains to be seen whether it should be built as part of the plow or whether it might better be built into the tractor drawbar.

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Machinery for Cotton Production

By Wm. E. Meek
MEMBER A.S.A.E.

COTTON is the overcoat of a seed that is planted and grown in the southern states to keep the producers broke and the buyers crazy. It is planted in the spring, mortgaged in the summer, and left in the fields in the winter. The fiber will vary in length and color, and the man who can guess closest to the length is called a cotton man by the public, a fool by the farmer, and a poor credit risk by his creditors. The price of cotton is fixed in New York, and goes up when you have sold and down when you have bought.

A cotton buyer was sent to New York by a group of mills to watch the cotton market, and after several days deliberation wired his mills as follows: "Some think it will go up. Some think it will go down. I do too. Whatever you do will be wrong. Act at once."

Machines for the growing of cotton vary greatly even in the same locality, and in this paper I will consider only a few of them. A farmer may have few or many machines depending on his method of farming and his particular soil conditions.

Here in the Southeast where the soils are light and easily worked, the one-mule farmer has become a fixture. Here we have the minimum requirements for tools to make a cotton crop, *a la* one mule. Let us see just how little a farmer on the lighter soils of the South will actually require to make a crop. It is pitifully little when we consider the amount of labor he must expend as a penalty.

First, he must rid the field of last year's stalks. This can be done by knocking them down with a stick or rooting them out with a scooter plow. If the scooter is used, it is attached to a Georgia or ratchet stock, the basic tool of the one-horse or one-mule farmer.

After the stalks are disposed of, he has the plowing operation, and so he changes from a scooter to a turner on the stock and has a plow. If he desires to bed out to form the familiar cotton bed, he changes again, replacing the turning shovel with a middlebreaker blade, and the stock becomes a middlebreaker. After the beds are prepared, they are ready for fertilizer to be deposited.

The stock undergoes another change, and we have it again with the scooter opening up a furrow for the fertilizer which is deposited with a bugle or long tube with a funnel top. The fertilizer is carried in a sack slung from the shoulders. If the farmer doesn't need the cloth sack the fertilizer comes in for a new pair of pants, it may be used, otherwise a gunny sack will fill the bill.

Paper presented before the annual meeting of the American Society of Agricultural Engineers at Knoxville, Tenn., June 1941. Author: Special sales representative, International Harvester Co.

For chopping he will need a hoe. An eye or Scovil hoe is usually preferred, and for a handle a nice clean sapling from the creek bottom is ideal.

Planting is done with a Daw-Low or some cheap slobber-drop planter, and while these planters are wasteful of seed, obsolete and primitive in design, they usually give a good stand of cotton. They have been in use for many years and will probably be used as long as animal power is used in making cotton.

For cultivation, we go back to the stock with a wide variety of sweeps, shovels, scrapes, etc. The variety and combinations are a matter of locality and opinion.

For power, the farmer will need a mule, or perhaps he prefers an ox, or "bull" as they are usually referred to. He will need gear or harness, and then he is fully equipped. He only hopes that he will need a pick sack in the fall. He already has his mortgage which is standard equipment. Here is a list of minimum equipment the farmer will need:

Mule	$25.00
Set of gear (harness):	
Bridle	.75
Collar and pad	1.40
Pair of hames	.75
Pair of trace chains	.65
Backband with buckles	.25
Plow line (1)	.10
Singletree	.50
Georgia stock	2.50
Turning shovels (2)	1.20
Middlebreaker blade	1.75
Scooters (2)	.60
Scrapes (3)	1.10
Shovels or sweeps (2)	.70
Fertilizer bugle	.60
Daw-Low planter	6.50
Scovil hoe (2)	1.20
Pick sack (2)	1.50
Drag (log) chains to make	.50
Slide for hauling — nails to make	.05
Total	$47.60

Following is the number of miles walked (per acre) in making a crop of cotton with one-mule equipment; it is figured on the basis of 36-in rows, 70 rows to the acre and 70 rd long:

Knock stalks (hoe, stick, or scooter)	2.78
Break land	19.80
Mark rows	2.78
Bed land	2.78
Fertilize:	
Open beds	2.78
Deposit	2.78
Cover	2.78
Plant	2.78
Chop (3)	7.26
Cultivate (6)	33.36
Pick (2)	5.56
Total for 1 acre	85.44
Total for 15 acres	1281.60

These figures are average prices for the season of 1941 and will vary slightly as to price in the various localities.

A better mule or better plow would increase the cost. The crop of fifteen acres would be about average for one mule and it is very evident here as in all forms of agriculture that as the investment in machinery goes up, the farm income will also rise in proportion. Our tenant farmers, farming with one mule are probably the poorest paid workers in the United States today.

With better machinery, we still have the same problems to consider whether the outfit be one mule or a four-row tractor. The stalks must first be removed from the land. A heft stick in the hands of one willing to swing it is the most primitive method. Next we have the hoe by which the stalks are cut down. Then a primitive improvement is the log cutter. This latter is a log with bolts driven into the ends to form axles and fitted into a wooden frame. Blades are attached to the log, and it is drawn through the field by one mule. All these methods (in fact, most methods) work better when the frost is on the ground and the stalks are brittle. Leaving the homemade outfits, we have the one and two-row revolving drum cutters pulled by horses or mules. For tractor operation there is the drum cutter which is very similar in design to the log cutter, except that it is made of steel and is drawn at high speeds by tractor power. These are available in two and four-row sizes and are very efficient machines, due to the weight of the machine and the speed at which it is drawn through the field.

In some sections the farmers take a tractor disk harrow and cut the stalks as they disk the land. Others take a tractor middlebreaker and plow the stalks under. Where tractor plows are used, the stalks are seldom cut before plowing, although it is always better to run a cutter over them so as to have less interference when cultivating.

For plowing we have everything from the Georgia stock with turning shovels and the light 5-in cast or steel plow on up through the complete line of horse-drawn walking plows, wheeled horse plow, both bottom and disk, and then the various tractor plows—disk, moldboard, harrow, or wheatland, etc. In light soils the wide-spaced disk harrow is often used rather than a plow, though it is far from satisfactory when cover crops are on the land. In the terraced lands the direct-connected plows are particularly well liked as they may be made to operate in building and maintaining terraces on much steeper slopes than trailing plows.

THE MIDDLEBREAKER IS ONE OF THE IMPORTANT IMPLEMENTS IN COTTON PRODUCTION

Middlebreakers are used in many sections both before and after plowing. In the lighter soils they are usually used after the plow or the disk and here the Georgia stock comes back into the picture. The light one and two-horse middlebreakers are widely used, and in the river bottom areas we have the large "four-up" middlebusters. The tractor outfits are from one to four bottoms depending on the size tractor used and also on the territory. The four-row outfits can only be used satisfactorily on rather level lands and are popular in Texas. Many farmers bed out—throw the old rows out by splitting them with the buster and then rebed. After the new beds are settled they are reversed before planting. This gives the effect of two plowings. Continual use of the middlebreaker without plowing is apt to form a plow sole in many soil types, and while it is a most economical means of preparing land, its use should be carefully considered so as to fit soil conditions.

After plowing or "busting" comes the planting and fertilizing. Cotton is planted from the "flat" or level to high beds, and in some instances is even planted in a slight water furrow or drill. The seeds vary in their condition, three types being common. Probably the most common seed planted is the "gin run", or seed just as they come from the gin. The other type is delinted seed which are of two very distinct types and require different seeding equipment in the hoppers. The most popular type of delinted seed is the saw delinted which are processed by reginning. The other type seed is the acid delinted which is in appearance much like a bean and is planted with the same seed plates as beans.

The cheapest type of planter is the Daw-Low and other types of "slobber drop" feeds, so called because of the large quantities the feed pulls out and the rather sloppy way in which the seed is handled. Some are of a reciprocating gate feed while others have a revolving picker wheel of various designs. Cotton planters of the more improved type resemble corn planters very closely, and the hoppers are usually arranged to handle other crops such as corn and beans as well as cotton. They are made in one and two-row types in horse-drawn machines and from one to four rows in the tractor outfits. Some cotton is check planted, but this is the exception rather than the rule. It is usually drilled or hill dropped. The feeds most popular are the reverse feed and single seed. In the former a revolving spider or stirring plate turns towards a small picker wheel, turning in the opposite direction and in a vertical position, while in the single-seed hopper there is a seed plate similar to a corn plate with cutoffs to expel the seed from the cells. This is a more accurate feed, especially with the saw delinted seed. For hill dropping the single seed is also preferred as it gives a more uniform flow of seed from the hopper to the hill drop valve.

PROPER PLACEMENT OF FERTILIZER OF GREAT IMPORTANCE IN COTTON PRODUCTION

Fertilizer is applied at the time of planting, before planting, and as a side dressing with combinations of the first two and the latter. Types of fertilizer vary with the soil conditions and soil types. The cheapest fertilizer distributor is the bugle and sack. Next up the line come the knockers and vibrators in the one-horse machines. Some two-row horse outfits are also in use. Fertilizer placement is of great importance, and a few of the horse-drawn planters are now designed to give proper placement at time of planting. Because of trash and grass in the fields, these planters often lack clearance and clogging is apt to result. The tractor-mounted fertilizer distributor is probably the most efficient and best of them all. Here the same fertilizer unit can be used in one or two-row outfits as a combination machine with the planter and also as a side dresser. In the Southeast the combination of cultivator to build beds or open water furrows with the fertilizer attachment and the planter opened a new era for tractor farming.

After planting the cotton is chopped when it is several inches high, first to a stand, and then usually again to clear the drill of weeds and grass. This is a hand job for though there are mechanical choppers on the market, they are of little value except to block the cotton to a stand. Check-row planting eliminates chopping almost entirely.

For cultivation, we come back to the stock with the various shapes, blades, and scrapes. The one-horse cultivators are too numerous to mention, but suffice it to say that there is the double shovel, spring tooth, top-harrow, and side harrow to mention a few. Full-row or two-mule cultivators are in both the walking, riding, and combination walking and riding types. Some two-row mule cultivators are used but they are the exception rather than the rule. The two-row cultivator has about lost out in favor of tractor cul-

tivators. Tractor cultivators are in the one, two and four-row types and carry a wide range of tooling equipment. Because of their better work they are fast becoming numerous in the cotton belt.

Cultivation is probably the biggest power job in a cotton crop aside from seedbed preparation and often is a greater job than even that. Cotton is cultivated from five to nine times depending upon soil conditions and the season. It is cultivated from the time the plants are only a few inches high up until it becomes difficult to get machines through the field without damaging the bolls.

Cotton fruits with a bloom very similar to that of the okra plant. The first indication of the boll is after the bloom drops and the immature boll is seen in the square. From this point on there is the fight against the boll weevil and various worms and bugs. Poison machines are used and are of a great variety. The mops which put a liquid poison on the plant are common in the Southeast. Large ground-driven dusting machines and saddle guns are all in use. With the tractor the dusters cover from four to twelve rows when used as row dusters. Some dusters broadcast the poison, covering from fifty to seventy rows depending upon the wind drift. The broadcast method is not as economical or efficient as the row machine. Airplane dusting is much favored in some sections and is efficient and fast. The trouble here is in the farmer being able to get a dusting plane at the proper time. Most farmers prefer to depend upon their own machines so that they can dust when it will do the most good.

If the bolls mature and escape the ravages of the boll weevil, too much hot weather, too much cold weather, too much dry weather, and too much wet weather, they mature and begin to open in August. By early fall the fields are white with fleecy open bolls, and the pickers are at work. This is also a hand job, and all rush to get the cotton to the gin before it is damaged by the weather.

Mechanical cotton pickers are not new, patents having been issued as far back as just after the Civil War. None to date have been sold commercially in quantities as they have either been inefficient or very complicated and expensive. With the advent of the present world war and the shortage of cheap labor on the farms, there is a revival of interest in mechanical pickers, and it is hoped that a simple, cheap, and efficient cotton-picking machine will be made available to the southern cotton farmer.

After the cotton is picked, it is hauled to the gin where the seed is separated from the fiber. Seed is shipped to oil mills for processing, and the fiber or lint is baled for shipment to mills all over the world. Cotton ginning is, however, a broad subject in itself and is making as much progress as the development of field machines to make the cotton cheaper and better.

Shelling Castor Beans

By H. A. Arnold and M. A. Sharp
MEMBER A.S.A.E. MEMBER A.S.A.E.

THE shortage of castor bean oil due to the war situation and commercial developments indicating expanded use in the future, has created a demand for machinery to harvest and thresh or shell this crop. The beans have been successfully harvested with a combine, but so far as we know there are no machines on the market which will shell the beans out of the pods.

The growing season in the South is favorable for castor bean production, so the agricultural engineers in the agricultural experiment station of the University of Tennessee have developed a machine for shelling this bean. There are so many interested in the shelling problem that we offer our development with the hope that it may contribute toward the ultimate solution.

The problem is to get the bean out of its individual part of the pod without cracking or injuring the hull or cover coat of the bean. When sufficient pressure is applied on the sides of the pod to break it loose, the bean is usually injured. By applying pressure on the ends of the pod, it may be readily removed without cracking the bean.

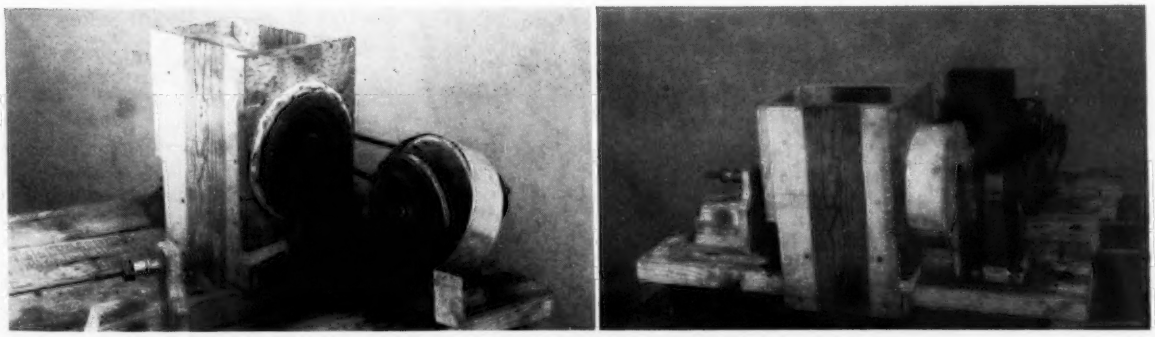
With the machine we have developed, we have been getting 95 to 98 per cent of the beans out of the pods without injury to them. Those not shelled may be screened out and put through again. The loose hulls may be blown out with any fanning mill.

The machine, shown in the accompanying illustration, consists of two rubber disks, one being stationary and the other rotating at about 1100 rpm, which are spaced about $\frac{1}{2}$ in apart and adjusted so the beans will just fit endwise between them without being crushed. Grooves are cut in the rubber disks so as to cause the pods to rotate in more than one direction. Thus pods which enter sidewise are turned so the pressure comes on the ends, and the pod is removed without injury to the bean.

The addition of rubber rings or ridges on the disks increased the percentage shelled, although they are not necessary. The rubber used is $\frac{3}{8}$-in tire stock sheets, and the grooves are V shaped about $\frac{1}{8}$ in wide and $\frac{1}{8}$ in deep.

This 6-in machine does a good job of shelling and has proven to be very satisfactory for our experimental plot work. It also does a fair job of hulling peanuts.

Authors: Assistant in agricultural engineering research and head of the agricultural engineering department, respectively, University of Tennessee.



Two views of the machine for shelling castor beans as developed at the University of Tennessee

Outlet Design for Terraced Lands

By Donald Christy
MEMBER A.S.A.E.

THE ESTIMATION of run-off is one of the more difficult problems of outlet design. The rational run-off formula may not be the most accurate method of estimating run-off, but it is the method most commonly used. The rational formula, $Q = CIA$, probably can be expected to give the most consistent estimates in the hands of the average agricultural engineer, due to the amount of data collected on its use.

The C of $Q = CIA$. The values of C as it is now used are available for varying degrees of slope, soil type, and cover, and can be compared closely with the effect of these factors in other run-off formulas. Contrary to popular belief, C may be larger than 1. I have records of C as high as 1.2 in enough instances to warrant a further critical examination of C. The accompanying chart C of $Q = CIA$ was worked up from present existing data. This chart takes into account soil class, land slope, area, and land use. Example: C for pasture with a land slope of 10 per cent fine sand, and less than 100 acres is indicated. A line from 10 per cent slope, through area of less than 100 acres, intercepts the guide line. Using the guide line interception as a pivot, the straight edge is moved to average land class, "fine sand". The C for cultivated land would be .84 and for pasture .42.

The I of $Q = CIA$. The value of I varies with locality, frequency, time of concentration, and surface storage. The effect of locality is well understood and considerable data are available on the variation of I with locality.

Frequency. The frequency is not so simple. It might be said, however, that a structure or outlet should be designed so that it is the cheapest in the long run. A structure which is inadequate in size requires excessive maintenance, whereas a structure of excessive capacity has a high investment cost.

Time of Concentration. The time of concentration is easy to figure, but the velocity of overland flow and of concentrated flow is difficult to figure due to limited data. The effect of slope, cover, soil type, and rates of rainfall need be considered. The data from the South Carolina soil conservation service handbook is probably the most complete at the present time.

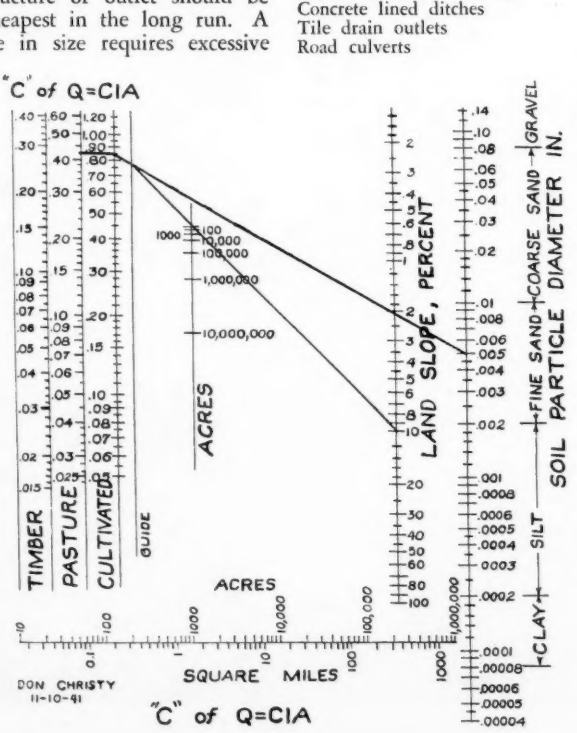
The maximum flood may not come from the rains lasting as long as the time of concentration. A long terrace, emptying water into a common ditch with a group of short terraces, may give a time of concentration of 35 min for a 22-acre field and a rate of run-off of $Q = CIA = 0.60 \times 4.4 \times 22 = 58$ cfs (cubic feet per second). If the long terrace is disregarded entirely, the time of concentration is only 14 min, and $Q = CIA = .6 \times 7 \times 17 = 72$ cfs. Thus the maximum 10-year floods come from only part of the field. This fact upsets the standard definition of time of concentration.

Area. The area drained is determined in one of three ways: The stake lines or the terraces are mapped on an aerial or plane-table map. The areas thus obtained are measured by planimeters. The area drained by the terrace may be determined by the lengths of the terrace or terraces multiplied by the average distance between the terraces as determined by measuring from terrace to terrace in a number of places. The areas may be determined from the field notes using the lengths staked times the horizontal distance between terraces obtained by vertical interval divided by the land slope in feet per foot.

The early flood flow formula varied the expected flood flow from various size watersheds, by including area to a power (A^n). The value of "n" varied according to the data on which the formula was based. A close check reveals that the larger the area the smaller the value of "n". Maximum floods plotted against area substantiates the fact that "n" decreases as the area increases. On small areas "n" = 1, while on drainage areas as large as the Mississippi, the value of "n" may be as low as 0.5. However, if the effect of area on C and the effect of heavy storms of less than time of concentration are considered, it may be that an "n" of 1 would be satisfactory.

TABLE 1. FLOOD FREQUENCY FOR WHICH STRUCTURES ARE DESIGNED

Structure	Flood rain frequency (years)
Vegetated terrace outlets	10* - 25
Check dam terrace outlets	10* - 25
Concrete lined ditches	10 - 25*
Tile drain outlets	10* - 25
Road culverts	5 - 10 - 25



Unit Hydrograph. The unit hydrograph principle might be used to estimate flood flows. It is, however, dependent on one recorded flow from a recorded rainfall, or it is dependent upon the time of concentration the same as the rational formula. In the unit hydrograph method the result of surface storage can be more readily calculated.

Paper presented before the American Society of Agricultural Engineers at its fall meeting at Chicago, December 1941. Author: Assistant professor of agricultural engineering, A. and M. College of Texas.

Outlet Cost. The cost of the terraces in the field affects the permissible cost of the outlet system. If the terrace system can be expected to increase the value of the land $10.00 per acre, when all factors have been considered, the complete cost of the terraces plus the outlets should not exceed the increased value of the land. If the terraces cost $5.00 per acre, the outlet system should not cost more than $5.00 per acre. If the terrace system costs $1.00 per acre, the outlets could cost as much as $9.00 per acre and still be justified.

The selection of the outlet type might be aided by cost figures computed for a number of typical fields as exemplified in Table 2 and based on the costs indicated (Scoates and Ayres).

It will be noted from the table that the constructed ditches cost from $146, or $3.65 per acre (check dam controlled on 1 per cent slope) to $1495.00, or $37.38 per acre (also check dam controlled on a 12 per cent slope). The vegetated ditch becomes the least expensive constructed ditch on slopes greater than 4 per cent. However, the vegetated ditch outlet costs from $11.00 to $13.50 per acre. This cost is in general more than the terracing system is worth, especially when the cost of the terracing is added to it.

THE MEADOW STRIP OR PASTURE OUTLET MAY BE SOLUTION TO MANY OUTLET PROBLEMS

The meadow strip or pasture outlet, established in the field, may be the solution to many of the outlet problems. The pasture may be usable, in which case the only cost which can be rightfully charged to the terrace system is the cost of establishing the sod. The usable pasture outlet would cost $60.00, or $1.50 per acre of terraced land.

If the pasture is not needed and returns cannot be expected from it, then the cost of sodding plus the value of the land used should be charged to the terrace system. In Table 2 the land was valued at $40.00 per acre. The outlet cost including the value of the land involved, is only $220.00 or $5.50 per acre.

It is an established practice in a few areas to turn the water into a strip of waste or low value land. No effort is made to save this waste land. In other words, it may be cheaper and more feasible to turn the water on a strip of land and allow that strip to wash away, than to try to protect the outlet. My observation has been that this practice is only satisfactory where rock is near the surface. The resulting gully is shallow, and terrace-channel gullying does not occur. Many of our Texas soils are relatively deep. Unprotected outlets result in deep gullying followed by channel gullying and field subdivision.

Road Ditches. Road ditches may or may not be a good outlet. In some cases a road ditch cannot be avoided if a feasible terracing system is to be attained. The successful use of a road ditch depends upon the cooperation of the land owner and the highway department. The land owner must do his part of the road ditch maintenance, especially the stopping of small washes. The highway department must help build the ditch, and, more important, must insist that mowing, not burning, be practiced. The maintainer must not be permitted to go into the ditch to get dirt for the road. If all parties interested will work together, it is cheaper to design and maintain a combined road ditch and outlet than it is to maintain two drainage ways.

THE COST OF THE TERRACE OUTLET MUST BE FIGURED ON THE LONG TIME BASIS

Outlet Location. Much has been said and written regarding the desirability of locating the terrace outlet in the natural depressions of the field. In my experience, the constructed vegetative outlet on the steeper part of the field has been the shorter and less expensive outlet. It is only so many feet vertically from the top terrace to the bottom of the slope. The outlet on the steeper slope is then the shorter outlet. The problem involved is one of correct design. Undoubtedly the steeper outlet will require more maintenance. The soil is normally poorer and the grades steeper. The ridge outlet may make the more valuable land in the depression usable.

It must be remembered that the outlet cost must be figured on the long time basis. An inexpensive outlet that requires a high yearly maintenance is expensive. I feel that at least $20.00 can be spent for the elimination of $1.00 annual maintenance.

Vegetated Ditch. The vegetated ditch seems to fail as often from a low design velocity as from an excess velocity. A study of a large number of vegetated ditches indicated about 80 per cent of the ditches were working satisfactorily. When the design velocity dropped below 2 fps (feet per second), silting caused a high per cent of failures. When the design velocity was more than 8 fps, the per cent of failures was high due to erosion. These ditches were on the heavy black land soils of central Texas. The designed flood flow frequency was 10 years.

It is difficult to determine the actual safe design velocity; outlets designed for velocities of 12 fps have worked well while others designed for velocities of 5 or 6 fps have failed. Apparently the amount of silt carried to the outlet affects the performance.

TABLE 2. ESTIMATED COST OF A 1000-FT OUTLET DRAINING ONE SET OF 1600-FT TERRACES DOWN SLOPES RANGING FROM 1 TO 12 PER CENT. ABOUT 40 ACRES ARE PROTECTED

	1 per cent slope			4 per cent slope			8 per cent slope			12 per cent slope		
Type of Outlet	Labor	Mat'l.	Land	Labor	Mat'l.	Land	Labor	Mat'l.	Land	Labor	Mat'l.	Land
A. Sod-lined ditch	60.00[7]	360.00[6]	20.00	50.00[7]	430.00[6]	20.00	35.00[7]	330.00[6]	20.00	60.00[7]	460.00[6]	20.00
B. Pasture or meadow strip, usable		60.00[9]	0.00		60.00[9]	0.00		60.00[9]	0.00		60.00[9]	0.00
C. Pasture or meadow strip, nonusable		60.00[9]	160.00		60.00[9]	160.00		60.00[9]	160.00		60.00[9]	160.00
D. Check-dam controlled ditch	56.00[4]	75.00[5]	20.00	120.00[4]	350.00[5]	20.00	210.00[4]	760.00[5]	20.00	275.00[4]	1200.[5]	20.00
E. Concrete-lined ditch	130.00[8]	1120.00[5]	5.00	100.00[8]	900.00[5]	5.00	95.00[8]	875.00[5]	5.00	90.00[8]	775.[5]	5.00
F. Drain tile	65.00[2]	455.00[3]	1.00	68.00[2]	600.00[3]	1.00	68.00[2]	600.00[3]	1.00	70.00[2]	695.[3]	1.00

[1]Land value figured at $40.00 per acre
[2]Excavation and backfilling
[3]Tile, inlets at $7.50 each, and outlets at $15.00 each
[4]Excavation at 20c per cubic yard
[5]Concrete at $18.00 per cubic yard in place
[6]Sod cost figured at 15c per square yard
[7]Excavation figured at 15c per cubic yard
[8]Excavation figured at 25c per cubic yard
[9]Sodding cost $15.00 per acre figured for a quick sod

The side slopes of the ditch should be made flat enough for easy moving. The flat side slopes are damaged less by grazing livestock. A farm operator will keep the weeds down better by mowing where it is easy to do so. Where it is necessary to have a bend in the ditch, the centerline radius of curvature probably should be about three times the width of the ditch. Natural streams have about this radius of curvature unless obstructions modify the regime.

It has been observed that the ditch gradient variation caused considerable variation in calculated bottom width of the ditch. If the ditch is not narrowed to compensate for steeper grades, a critical erosion point occurs where the grade starts becoming steeper. If strip sodding is used to establish the sod, solid sodding may be required wherever the grade is increasing. On the other hand, a decreasing grade may not require any sod. The uniformly graded part of the ditch then requires only enough sod for quick coverage. The development of mulch sodding reduces this consideration in many cases. Mulch sodding is cheap and, if properly handled, effective.

Meadow Strip. The minimum meadow strip outlet in a slight depression is generally 50 ft wide at the first terrace and should be 20 ft wider for each added terrace. If the outlet is on level ground, this width should be doubled, and if on a ridge, it should be three times the above widths.

THE MEADOW-STRIPPED AREA SHOULD BE LEVELED TO ELIMINATE WASHES OR PATHS

The area to be meadow-stripped should be levelled by fresno or drag to eliminate all washes or paths. The sod should be thoroughly established before the terraces are built. Livestock and farm machinery should not use the meadow strip as a pathway. Paths which develop in the meadow strip are an erosion hazard.

If an aggressive grass such as Bermuda is used as the outlet cover, a non-aggressive grass may be used between the Bermuda and the field to partially prevent the spread of the obnoxious grass to the field. Sometimes a cow trail or a road may be used to help prevent the spread of the undesirable grass.

Check Dams. The check dam has been widely used as a means of protecting the outlet. Excellent research has been carried out with regard to the flow hydraulics. There are, however, a number of practical problems involved. For instance, a particular ditch controlled by check dams gave trouble. A major rain did not occur without leaving one or more dams high and dry. A large rock was placed at the junction of the apron toe and the splash walls. The rocks kept erosion away from the bank, and subsequent failures were eliminated. The splash walls were vertical; as a result the ditch bank had to make the transition from a vertical to a 1½ to 1 slope at a point subject to considerable turbulence.

Bentonite, sand, gravel, rock, and straw in the order named have been used as a fill material after each washout of a particular check dam. The results are all alike—failure. The water goes directly under the middle of the dam even though the cutoff wall goes some 14 in below the floor. I have come to the conclusion that a deep plane of weakness exists in the soil. During a drought the crack opens even deeper than the fill. The result is obvious.

The crack between the head wall and the soil behind it may be as much as 4 in wide and 2½ to 3 ft deep in the colloidal soils. In addition, the deep set wings in moist soil may actually hold the dam up while the soil shrinks from behind and beneath the dam during dry weather.

We built a large number of check dams with vertical splash walls which sloped from the top of the head wall to the toe of the dam. The water falling on the slope above the splash wall removed the dirt from behind it. The result was a greater tendency for the water to go around the end of the wing walls. This trouble was overcome by making the wing wall higher at the toe of the dam than at the head wall. The transition between the vertical earth wall was then taken care of by warping the splash wall from vertical at the notch to 1½ to 1 slope at the toe.

Holes formed at the toe of the check dams are a source of mosquitoes in some areas. Mosquitoes mean malaria.

THE CONCRETE-LINED DITCH SHOULD BE SET WELL BELOW THE GROUND SURFACE

Concrete-Lined Ditches. The concrete-lined ditch is difficult to design. These ditches are cheapest when the steepest part of the field is used as an outlet. The result is high velocities. The velocities may be so high that entrained air swells the calculated water volume by some 25 per cent. The slow moving water from a terrace spilling into the high velocity ditch may cause a hydraulic jump and overflow in the field. The high velocity ditches also require expensive checks at the foot of the slope.

The concrete-lined ditch should be set well below the ground surface and the earth banks should be well sodded. Some of the ditches were washed by water running alongside the ditch. The ditch support was removed and as a consequence the ditch fell in the wash.

Tile. The tile outlets were designed to handle the flood run-off on the same basis as the other outlets. The tile outlet problems encountered were the entrance of water into the tile and prevention of trash blocks across the ends of the tile.

A tile used as an outlet acts as an orifice rather than as a pipe. In other words, the opening into the tile determines the capacity. Every effort was made to enlarge and smooth the entrance to the tile from the shallow manhole.

The manhole entrance was covered with a mesh designed to retain any trash which would plug the tile. A doubled woven wire fence 10 ft in diameter was placed around the manhole and provision was made for the water to enter from all sides. The service record of these outlets was excellent, but the cost was high.

CONCLUSIONS

1 Most constructed outlets are so expensive that they cannot be justified from an economic point of view.

2 The meadow strip has possibilities as an outlet even when the value of the land used is charged to the outlet.

3 It may be cheaper and more satisfactory to use the steepest part of the field as an outlet rather than the more valuable natural depression.

4 The road ditch may be a satisfactory outlet providing farmer and highway department cooperation can be secured.

5 It may be cheaper for the farmer and the public to allow some cultivated land to erode than to attempt to terrace and construct expensive outlets.

6 The rational run-off formula, while subject to considerable error, will give satisfactory results in the hands of the average agricultural engineer.

7 The best outlet engineer is one who can, after a critical analysis of labor and materials available, design the least expensive serviceable outlet, and is not the man who can, with unlimited funds, labor, and material, build a great monument.

Agricultural and Industrial Research Parallels

By Dr. Anson Hayes

PRIOR TO some twenty years ago, essentially all basic research in chemistry, physics, and mathematics, as well as in the so-called derived sciences, was done in university and other institutional laboratories. Then industry found it could use sufficient portions of the accumulated knowledge of these laboratories to justify representatives of industry visiting professors for discussion of practical problems. Quite naturally the next step was to employ the professor full time in industry, thus making it possible for him to devote his entire time to research for industry and relieving him of his teaching job.

The first activities of these industrial men consisted largely of combing the scientific literature for facts applicable to manufacture. Frequently the industrial research man found need for information in connection with his company's activities which did not exist in the archives of collegiate research. By this time the value of the results of scientific investigational work had grown sufficiently so that certain industrial managements were willing to employ men to develop such new information. Up to this time science had developed largely without financial encouragement, but the world was turning of necessity into a practical economy.

In view of what has just been said, industrial research as we know it today is a new activity. Its development has largely taken place during the lives of many of those present here today.

Whenever a movement takes place, such as that of the establishment of extensive facilities for research in industry, there are always sound reasons and strong forces that account for such changes. I think it is safe to assume that in business movements of any considerable importance, the motivating force turns out to be directly the hope of financial gain. The growth of research in industry is no exception. I believe that financial gain can be found to have been realized partly from each of two factors, namely, (1) more research facilities were needed, and (2) research facilities were found to be more effective for the purposes which they serve when placed in industry.

I believe the Committee on Research of the American Society of Agricultural Engineers desires that in this symposium some of those factors that make for greater effectiveness in research be brought into view so that all research can better take advantage of them. The current crisis has made not only scientific groups cognizant of the importance of research, but the public is expecting research laboratories to produce miracles in the midst of present-day shortages of previously abundant materials.

It is proper at this time to focus attention on the many laboratories, of all classifications, which are capably, cheerfully, and promptly assuming responsibilities in our nation's hour of need.

However, it would not be proper to confine this discussion to the purely industrial aspect of research. Fundamental work, and particularly scientific work, has made our present stage of development possible and has a very important role to play now and in the future. Particularly is this true in defense and in the advancement of the way of life which we are defending.

It is a fact that the rapid development of industrial, as well as university research, has raised in the minds of those closely associated with its activities many questions as to the wisdom of placing research in industry rather than establishing more of it in the university. There has been the feeling on the part of some that industrial research lacks scientific quality. No doubt this statement can be made in regard to certain portions of all types of research. Misapprehension has been in the minds of university men as to what would be the status of research in the university when the new movement of research in industry had made its full development.

I believe at present most of those misgivings have disappeared and that the university man, as well as the industrial research worker, sees his place in the new scheme of things. It is to be expected that more research will be demanded and that it will be done wherever it can be done effectively. Nothing further should be cause for concern. It should be noted, however, that wherever research is conducted effectively in the future, it will have been done under more stringent competition in development work.

Industrial, agricultural, and university research now are concerned with means of improving the effectiveness of their endeavors. So what I shall have to say will be aimed at some principles which experience has led me to believe are important in making research effective. These principles are sufficiently fundamental to make them effective wherever they can be applied. To show that this is true, I have chosen to scan an important research development in agriculture and another in industry.

Before entering into the tracing out of these parallels, it should be noted that research in agriculture is probably one of the oldest fields in which organized research endeavor has existed. In its most effective forms, its organization represents the best that is known in industrial research today. I am thinking particularly of some of the outstanding agricultural experiment stations of our land grant colleges. The American Society of Agricultural Engineers should take great satisfaction in being an important integral part of the scientific progress in the oldest industry with its oldest research traditions.

I know of no development in any field of research of greater importance and of greater beauty of technique, or one of greater courage and determination of purpose than that which Lester Pfister demonstrated with hybrid corn. He drove his experiment through to a successful conclusion by having a set objective. There can be no successful conclusion to any experiment without such an objective.

Certainly Pfister is a realist. And like most realists, he was subjected to the adverse criticism of his friends. He started his experiments with several essentials. He had an objective, he had a program for obtaining that objective, he had the necessary vision to refit his program to new situations that developed as his program proceeded, and he had tenacity to carry such programs through to a really finished job even in the face of his critics. His quest for hybrid corn started by inbreeding high-grade Krug corn. The technique which he used in inbreeding was that which had been in common practice for some time.

His first harvest resulted in some desirable characteristics with many undesirable ones cropping up. Some had

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An address before the fall meeting of the American Society of Agricultural Engineers at Chicago, December 1941. Author: Director of research, The American Rolling Mill Co.

strong stalks, some had stout roots, some had poor ears. Throwing aside the undesirables, he kept only the ears which showed promise and planted them the next spring. After five years with the processes of elimination adopted, he had four ears left! But the corn plants which these represented were rugged with excellent root systems that went deep into the earth for sustenance; they were straight and strong and unaffected by high winds; they were unusually resistant to certain types of disease.

After five years of inbreeding, Pfister started cross-breeding. Planting the corn in three rows, he let the middle row be the pollinator and snapped off the tassels on the "female" stalks as soon as they appeared, thus the "male" tassels were free to shed their pollen in the silks of the rows on either side. That winter he found he had produced an exceptionally fine grade of corn. Still dissatisfied he obtained federal inbreds to cross with his own. In the meantime his farm was going to wrack and ruin; his acquaintances openly laughed at him; the bank was ready to foreclose on his land.

Then came the harvest which produced 225 bushels of the finest corn ever seen in Woodford County, Illinois. They were all double crosses, a mating of single crosses of the preceding year. Pfister's corn would outdo anything he knew. He now has a seed business that represents in the neighborhood of $1,000,000 a year. He has given America yields which were unknown a few years ago. Pfister and others who have entered the field, have now been so successful in isolating the desirable characteristics and combining them into one individual that the farmer can now order seed for corn which has about a complete made-to-order set of qualities.

THERE ARE STRIKING PARALLELS IN AGRICULTURE AND INDUSTRY IN THE RESEARCH APPROACH

I have been unable to determine what was in Pfister's mind in the early stages of the work on hybrid corn. I am sure, however, that he must have had in mind certain important characteristics which he had observed in certain individual varieties of corn and which he believed he could confine, through breeding, in a single variety. Such things, for example, as well-shaped ears, deep grain, small cob, drought resistance, wind resistance, strong stalk structure, ease of husking, ease of shelling, high food value with respect to starch, protein, oil, adaptability to soil and climate, and of course high yield per acre.

There are striking parallels in agriculture and industry in the approach research men use to a desired objective. Basically, agricultural research men and industrial research men set the same pattern for their labors. They know the desired characteristics of the product they wish to bring forth and apply the same principles in achieving that successful conclusion. To follow these principles through in considerable detail in each case, I would like to cite an interesting development conducted by The American Rolling Mill Company in which you will recognize the fundamental pattern of agricultural research as we strived to produce a safer, better railroad wheel.

Pfister wanted a perfect corn, we wanted a railroad wheel resistant to internal stresses developed in service, a wheel which would not fail even if extremely severe and unusual conditions should result in thermal cracking. We put more than five years of intensive research into the development of this new railroad wheel. Our engineers had sensed the need for such a wheel beginning with the development of modern, faster railroad transportation. Accordingly, a comprehensive research program was set in motion to ascertain how these increasingly severe conditions could best be met. Previously the only method of testing wheel performance was to put the wheels in actual service. This, obviously, had many disadvantages. Therefore, we developed a wheel-testing machine which simulated actual service conditions but with precise control. With this machine it is posible to simulate the effect of hundreds of thousands of actual service miles within a comparatively few hours. The objective of our engineers was to find a means of developing failure in standard car wheels; then, through scientific study, determine the causes.

Examination of wheels in service had shown that thermal cracks might be the source of wheel failures that could cause a serious wreck. Thus resistance to thermal cracking was established as a primary requisite of a safer wheel. It was also determined that low initial stresses and resistance to the effect of cumulative service stresses were related to the problem and equally important.

AN EXAMPLE OF HOW RESEARCH HELPED EVOLVE ACCURATE AND RAPID TEST METHODS

The problem was attacked by close examination of wheels in service; then metallographic studies were made of the changes in wheel structure that occurred in wheel treads after breaking action. It was learned that when thermal cracks appeared, there was invariably a change in the structure of the surface layers of the tread. This led our engineers to a logical explanation for thermal cracking. Because of the importance of following the changes in internal stresses in these wheels, it was necessary to devise a method of accurate stress measurement. Previous methods gave only incomplete results, which were entirely inadequate. The metallographic studies resulted in linear equations. It was reasoned that these equations could be projected into an algebraic table, and when this was done, the time for computation of stresses was reduced from a full day to an hour and a half. Then it was reasoned that the equations could be converted into a special slide rule. This was done and the time was reduced for computation to but a minute or so.

Of even greater importance than its contribution to the ultimate construction of a railroad wheel resistant to thermal cracking, this slide rule and method enable our metallurgical engineers to study the effect of manufacturing variables on internal stress. The method is now widely used by engineers in other fields and makes possible the accurate computation of maximum stresses and the determination of their direction.

We have said that there are certain important factors in research that are common to all fields of research endeavor. We have just presented a bird's-eye view of the development of hybrid corn, an important piece of work in the field of agriculture, and also you have just seen such an outline of the development of a railroad wheel. Let us take a look at some of the things common to all research.

Let us consider the facilities of a research plant, namely, buildings, scientific equipment, personnel, customers' plants, and the production department. This list is motivated by the personnel, so let us look at the problem faced by the modern research worker in this direction.

How are we going to know when we have a good research man to make the wheels click? The primary requisite for a good research man is of course extreme interest in the problems he works on. This was all Edison had at the beginning. If a research man just can not get a problem off his mind until he has carried it through to a successful conclusion, he will be a good man.

Naturally, if the embryo research worker is asked, "Are you interested in research and what it means?" he will answer "Yes". He must be tested. How then can the quality of intense interest be determined?

Our company makes it possible for research men to start work in the plant itself. There they can be observed on the scene of production. They are brought into the laboratory for hourly work and that provides an opportunity to get acquainted with their personalities. Before they are actually launched on a research problem, we have had an opportunity to soundly judge if the newcomers actually have the "interest" they need for success. It is actually preferable to have a research worker who is brimming with interest but without training to a worker with training who has no interest.

Of course, the research man should be well trained in the fundamentals, in his high school and college studies, that is, chemistry, physics, mathematics, and the derived sciences needed in the particular field of endeavor. But when one is *allegedly* well prepared in the so-called fundamentals, it is astounding to realize their inadequacy to deal with the situations with which a research worker is confronted. However, given a man with fundamentals and an indefatigable desire to find the right answer, everything else will arrange itself. The particular phase of research in which he will have the greatest prowess, will be an avenue into which his characteristics will naturally carry him.

INTEREST, TALENT, AND ENVIRONMENT ARE ESSENTIAL TO SUCCESS OF THE RESEARCH MAN

Equally important as the spark of interest is the setting in which the research man's talents are placed. What should his environment be? Experience dictates that the research man should be given whatever scientific instruments he needs to accomplish what he wants done, so far as they are available. Many times he must develop new ones. He should be constantly familiar with the factors which bear on his work.

He should know the customer and what the customer expects. He should be able to anticipate the customer's future needs. Our company accomplishes this, in part, through a cooperative development program with customers, incorporating stated requirements of advanced models. A "clinic", held well in advance of the introduction of the new models, provides an opportunity to find out just what the customer wants the material to accomplish. Perhaps we have the desired characteristics already developed. Perhaps there are six months of development work to be done before the material for the new product is ready. But by having a central theme of familiarity with the customer's desires, the research man can intelligently and objectively set in operation, without waste motion, the facilities of his laboratories and his company as a whole.

Most of you are familiar with the work being done by the agricultural experiment stations. They have already done this job of becoming familiar with the "customer's" needs and proceeding to fill them. Agricultural engineers at the experiment stations concentrate on the problems, carefully selected, for which there is the greatest need of solution in the field. The farmer is the customer of the agricultural engineer. Certainly the way that experiment station workers have gone out and contacted the farmer to ascertain his needs, so that research for his benefit might be objective, is the same road that industry is now following. Agricultural research has not only accurately determined the need for important lines of development; it has done an excellent job of enlisting the farmer in projects which it pursues.

An industrial research man should be familiar with the production department of his company. It is not possible to give a man broad responsibilities in research unless he knows exactly how and what the production facilities can turn out. His development of materials or a process can more readily stem into the channel of practicality if he knows from what base he is operating.

Knowledge of sales problems and procedure is also important. It is to no avail to know only specified requirements of customers if the technique of presenting the finished material is foreign to the research man. There are many ramifications and much finesse in the selling of materials, and, since research in industry is tied directly to production for a profit, it goes without saying that a familiarity with its sales department is essential.

THE RESEARCH MAN SHOULD BE ASSOCIATED CONSTANTLY WITH SCIENTIFIC SOCIETIES

The industrial research man should be associated constantly with scientific societies relative to his endeavors. Further, the research man should have close and unrestricted contact with groups in his own organization so that facts developed in one group may be available to other groups. Every single one of these environment factors is applicable, with modification, in agricultural research, particularly that which is conducted in the experiment stations.

Many of the methods of research and methods of organization, which have been proved effective in industrial research have long since been used in agricultural research. For example, agricultural research administration is concentrated in the office of the director rather than in the subject-matter departments. Deliberate planning of research projects, resulting in systematic, orderly, and complete scientific attack and the emphasis on objective research, are all familiar components of agricultural research now found in industrial research organizations.

There remains for expansion, in our discussion of organization, the subject of close and unrestricted contact with groups within the research man's own organization.

Let us not gloss over the importance of *esprit de corps*; and let us not negelct to recognize that there is often a smugness in research which builds barriers against confidence and group consciousness. There is no place for such impediments to science in *any* research organization.

To those educators in this audience I would like to direct this thought. Never lose sight of the fact that the student is being trained to sell "services". When a student is turned out of a university or a college he must have that "service" product tuned to the times. He can not be a 1925 model in 1941. He must be provided with tools which will dismantle modern mental problems.

A student must be plastic in his thinking. For example, he will find upon entering a modern industrial research organization that experience points out the fact that purely scientific facts and the laws of logic *serve to mop up after an "accident"*, and it is the "accident" which points the way to major advances.

One of the best examples of accidents resulting in a major development in the field of scientific discovery was that of radio activity. In 1896 Becquerel was using an electroscope to measure static electrical voltage. Accidentally he discovered the electroscope would not stay charged. In attempting to find out what made the electroscope lose its charge, pitchblende was found to be causing the unexplained occurrence. It was the attempt to find out what the pitchblende was doing that brought to light radioactivity.

At that time, the knowledge of physics was believed to be essentially complete. Physicists were concerned with the future which seemed to be limited to refining systems of measurement. But the result of Becquerel's curiosity, when followed up, turned out to be the discovery of atomic decomposition or the transmutation of one element into another. From this development has resulted the entire field of our knowledge of atomic structures and all that has accompanied the development of the field of modern physics. A survey in the fields of pure science itself leads one to the conclusion that, with a very few exceptions, the greatest strides forward were the result of such accidental discoveries as have been mentioned in radioactivity and the development or knowledge of atomic structures.

In industrial research the part which accidental discovery plays is even more important. For example, following Henry Bessemer's accidental discovery that blowing air through molten cast iron produced steel, the Bessemer converter was developed and Bessemer steel produced.

Michael Faraday discovered unexpectedly that if he moved a wire loop in a magnetic field, an electrical current flowed in the loop. Out of this grew the entire field of alternating-current electrical power.

ACCIDENTAL DISCOVERY STARTED RESEARCH TO DEVELOP THE NON-AGING OF STEELS

Another excellent example of accidental discovery in our own company is in regard to the aging of steel. An order of steel sheets was made, to be pressed into a certain shape at the customer's plant. There was an unusual delay in the production line at the customer's plant, so the steel was not used for six months. When the customer finally got around to using the sheets, he discovered they would not stand up under the press which was to form them into the desired shapes. Informed of this our company investigated and found the qualities of the steel had changed during the six months' interval between production of the steel and its use in the customer's plant.

This discovery set in motion experimentation to make steel which would not age; which would have the same qualities six months or six years after it was made in the steel plant. The development of non-aging steels was accomplished, and as an outgrowth of that research and development have come even better steels for forming into such products as automobile fenders and countless other contributions to a better standard of living.

The most assured pathway between determination of a goal and arrival at that objective is to set up research in such a manner that the research worker will be subjected to as many unexpected happenings as possible. By exploring thoroughly these unexpected results, greatly accelerated progress is realized. Logic and fundamentals have a definite place in research programs, but essentially all great strides forward have come from "unexpected happenings". An unusual occurrence, provoked through an invited "accident" becomes a useful tool in a scientist's hands when logic is his companion to imagination.

Our company's research facilities are set up to *stimulate* the research worker *as much as possible* by exposure to "accidents". In a company where many thousands of tons of sheet and strip metal are made each month, one can be sure that sooner or later almost everything that can be done to sheet metal will be done. Observation of the unusual things that happen is one of the most effective means of developing suggestions on further improvements. So it is in any industry and in agriculture.

With the rather extensive parallel of common principles just outlined, it should be noted that there is one marked difference in the manner of financial support which is required by research in agriculture as contrasted with that in large industrial corporations. It is this: Many phases of agriculture are carried out by such small financial units that institutionalized research is necessary, that is, establishment of government bureaus, institutes, and university laboratories which are supported by the government. In large industrial corporations, well-rounded facilities in research can be supported by the company itself from funds which research enables it to earn.

It would seem that the very closely knit relation of research facilities in larger units of industry would offer less danger of duplication, of lost motion, and of lack of positive stimulation than would be the case in subsidized research in institutional laboratories. The high degree of effectiveness of some of our best agricultural experiment stations is evidence that such danger can be avoided.

IN ONE PER CENT OF 7,000 YEARS HAS OCCURRED 100 PER CENT PROGRESS IN MECHANIZATION

The history of mankind is recorded for approximately 7,000 years. Yet it has been only in the last seventy years that the world has enjoyed an advanced state of industrial civilization. How remarkable it is that in one per cent of the time that almost one hundred per cent progress has been made in mechanization as we know it today. Underlying this extraordinary development are two basic factors. One is the elimination of a lot of work through an understanding of the major forces in the physical universe, the other is the vast expansion in facilities for research, both in personnel and equipment.

With the unprecedented acceleration of the results of research, it is indeed interesting to contemplate what will be the nature of the world in which we will live a few years hence. With the rapid expansion of research and the organization of it to improve its effectiveness, it is to be expected that even more accelerated progress over that which has been realized in the last seventy years should result.

In view of the seventy-year background, we are new hands at this business. We have progressed through the accumulated knowledge of university and college research men, through the trial and error and labors of industrial laboratories. However, while *early* research in industry could be considered possibly as trial and error, that is no longer true. At the present time, in the setting that industrial research provides, while full advantage of trial and error methods is being taken, these methods are being supplemented in industry by fundamental scientific work of the highest character; and, too, university research is showing a willingness and a desire to prosecute lines of fundamental investigations more closely related to potential industrial uses.

There is no doubt that the results of scientific research should be more effectively supplemented by the efforts of those who are responsible for the social impact of science. There is great need for the preparation of the public in the constructive and intelligent use of the results of our scientific progress. We regret that at the moment in these turbulent times we must face the grim facts that research must direct a great deal of attention to the problem of our immediate national security and self-preservation rather than to the improvement of our standards of living and means of constructively taking advantage of them.

(EDITOR'S NOTE: A digest of the discussions that followed the presentation of Dr. Hayes' paper will be published in a later issue.)

The Effect of Mulching and Methods of Cultivation on Run-off and Erosion from Muskingum Silt Loam

By H. L. Borst and Russell Woodburn
MEMBER A.S.A.E.

DURING the summer of 1940 the authors conducted rain simulator studies of the effect of surface condition, mulches, and incorporated straw on the water intake of and erosion from Muskingum silt loam. A report of this work is now in process of publication. Some questions left unanswered by these studies prompted the work that is reported here.

One of these questions concerned the mechanics of the effect of mulching. When artificial rainfall was applied to bare plots that had been crusted or "sealed" by natural rains, at an intensity of 2.20 in per hr for one hour, both run-off and soil loss were heavy. (The pore clogging effect of rain-dispersed soil particles has been pointed out by Lowdermilk[8]*, Hendrickson[4], and Duley[3]. Baver[1] reported that Woolny in 1874 found that vegetal protection of the soil from rain-drop impact materially affected the non-capillary porosity of soils.) A straw mulch applied at a rate of 2 tons an acre to such plots curtailed run-off only slightly, but reduced erosion to a small fraction of a ton per acre. A similar mulch applied to plots, the surface of which had been broken by a slight cultivation, reduced both run-off and erosion to negligible quantities.

Some little study was made of the "why" of these findings. On the bare sealed plots two major erosive forces were in action, namely, (1) the dispersal and compaction of soil particles by the impact of the falling drops and (2) overland flow. (Nichols and Gray[10] have pointed out the tremendous kinetic energy of falling rain. Laws[7] shows photographic evidence of the destructive force of a water drop striking bare soil.) Since the mulched, cultivated plots did not reseal under the straw, as evidenced by continued high infiltration and low run-off, it was concluded that the chief function of straw here was energy absorption or protection from rain-drop impact. Since there was no run-off, overland flow did not operate. Where the mulch was applied to sealed plots, however, high run-off occurred, but the velocity of run-off was found to be reduced. The question remaining was: Under these conditions (dispersive action of impact nullified and velocity reduced by the straw) was erosion controlled by the reduction in velocity of overland flow only, or was protection from rain-drop impact still an important function of the mulch? The problem resolves into the relative potency of drop impact versus overland flow.

Importance of Drop Impact Compared with Overland Flow. To answer this question, partially at least, "sealed" plots with the straw mulch supported on hardware cloth 1 in above the plot surface were used. It was thought that under these conditions drop impact energy on the surface of the plot would be negligible, as in the case of surface mulch, while overland flow would be unrestricted.

Other plots with the mulch supported above a broken or cultivated surface were included in the tests for comparison. In addition, runs were made again on bare, sealed plots. The work with mulches on the soil surface was not repeated this season.

The plots were 6 ft by 29 ft, or 1/250 acre, and were on a 12 per cent slope of Muskingum silt loam. A type E rain simulator described in a previous publication[4] was used. (This is one of a number of such devices developed by the Soil Conservation Service at the hydraulic laboratory of the National Bureau of Standards.) Water was applied for 1 hr at approximately 2.25 in per hr. The results of the tests are compared in Table 1.

As in the previous work, both run-off and erosion were heavy from the bare sealed plots. From the supported-mulch plots, also, run-off was high (83 per cent), but erosion was very small. Soil loss was slightly more, but not

Paper presented before the American Society of Agricultural Engineers at its fall meeting at Chicago, December 1941, as a contribution from the conservation experiment stations division, office of research, U. S. Soil Conservation Service, and the Ohio Agricultural Experiment Station. Authors: Soil conservationist and associate agricultural engineer, respectively, Soil Conservation Service, U. S. Department of Agriculture.

*Superscript figures refer to the bibliography appended to this paper.

TABLE 1. RUN-OFF AND EROSION FROM BARE, SURFACE-MULCHED, AND SUPPORTED-MULCHED PLOTS COMPARING THE EROSIVE FORCE OF RAIN-DROP IMPACT WITH THAT OF OVERLAND FLOW

Condition	Treatment	Soil moisture,* per cent 0-2″	2-4″	4-6″	6-8″	8-10″	Run No.	Run-off, per cent	Density, lb per cu ft	Soil loss, tons per acre	Water application, in per hr	Chief forces operating
Bare soil, uncultivated for 9 months. Surface smooth and dry	None	12	15	14	16	17	25	88.2	2.82	9.95	2.21	Rain-drop impact. Free overland flow
Bare soil. Surface smooth and dry	Spaded 2 months before test	15	17	18	18	18	27	78.3	2.95	9.66	2.30	Rain-drop impact. Free overland flow
Bare soil crusted or "sealed" by artificial rain. Surface smooth and wet	None	24	22	22	22	22	52	82.7	1.45	5.62	2.30	Rain-drop impact. Free overland flow
Soil uncultivated—crusted. Surface smooth and moist**	Straw mulch (2 t/a) on soil	17	19	20	20	20		65.0	0.16	0.42	2.21	Negligible drop impact. Overland flow retarded
Soil uncultivated—crusted. Surface smooth and wet	Straw mulch (2 t/a) supported on screen 1 in above soil	27	25	26	24	24	53	83.2	0.08	0.26	2.20	Negligible drop impact. Free overland flow
Soil uncultivated—crusted. Surface smooth and moist	Straw mulch (2 t/a) supported on screen 1 in above soil	20	21	22	21	21	55	83.9	0.26	0.88	2.26	Negligible drop impact. Free overland flow
Soil surface broken**	Straw mulch (2 t/a) on soil	16	18	19	21	20		1.7	0.15	0.10	2.20	Negligible drop impact. Overland flow retarded
Soil surface broken	Straw mulch (2 t/a) supported on screen 1 in above soil	23	22	21	21	21	26	1.2	0.23	0.12	2.40	Negligible drop impact. Free overland flow

*Soil moisture percentages computed on dry weight basis

**Average of 3 plots, 1940

TABLE 2. RUN-OFF AND EROSION FROM PLOTS CULTIVATED AT DIFFERENT MOISTURE LEVELS

Treatment	Run No.	Plot No.	Soil moisture*, per cent 0-2″	2-4″	4-6″	6-8″	8-10″	Water application, in per hr	Infiltration (in per hr) after application had continued— 15 min	30 min	45 min	60 min	WATER LOSS Run-off, per cent	Density, lb per cu ft	Soil loss, tons per acre
Cultivated at optimum moisture content	28	2	15	16	17	18	19	2.32	0.48	0.34	0.30	0.30	77.2	2.95	9.60
	33	5	16	19	20	21	22	2.47	0.57	0.42	0.40	0.37	74.0	4.08	13.55
	35	1	16	13	14	16	17	2.43	—	—	—	—	74.7	3.88	12.78
Averages									0.52	0.38	0.35	0.34	75.3	3.64	12.0
Cultivated dry, worked into dusty condition	29	4	6	13	15	17	17	2.21	1.10	0.49	0.39	0.35	62.4	3.77	9.44
	32	2	3	14	16	16	18	2.20	0.97	0.50	0.30	0.25	65.4	2.35	6.15
	34	3	7	14	15	17	18	2.43	—	—	—	—	69.0	1.76	5.38
Averages									1.04	0.50	0.34	0.30	65.6	2.63	7.0
			23**	24**	25**										
Cultivated wet. Clods left to dry. Cultivated lightly before run	30	5	17	19	20	21	21	2.25	2.24	2.09	1.52	0.91	17.6	1.67	1.20
			22**	22**	22**										
	31	4	16	17	19	19	19	2.25	1.92	1.25	0.89	0.64	40.0	3.05	4.87
			22**	22**	22**										
	37	2	20	20	20	20	20	2.40	—	—	—	—	18.8	1.49	1.22
Averages									2.08	1.67	1.20	0.78	25.5	2.07	2.4
Bare, crusted surface†			7	12	15	16	17		0.37	0.37	0.28	0.23	79.2	3.23	10.0

*Soil moisture percentages computed on dry weight basis **Soil moisture percentage at time of first cultivation
†Average of 3 plots, 1940

materially so, than from the surface-mulched plots of the previous studies (Table 1). Run-off was somewhat greater from the supported-mulch plots than from those surface-mulched. Since the surface of the latter plots was dry and checked, while the supported-mulch plots were either wet or very moist and well sealed, difference in run-off should not be regarded too seriously.

On both the surface-mulch and supported-mulch plots drop impact was nearly nullified by the straw. Allowing free overland flow by supporting the mulch did not add materially to the erosion, so the reduction of the velocity of overland flow by the straw on the surface had little effect. It appears that, *under the conditions* studied, overland flow was of little importance as a factor compared to drop impact.

Further evidence of the dispersive power of drop impact was furnished by the following procedure. After one hour of water application to the supported-mulch plots, the screen and straw were quickly removed and the run continued. The run-off that had been nearly clear became muddy, and its density changed from 0.19 lb per cu ft to 1.15 lb per cu ft (average). This soil concentration was not as great as from the previous unprotected soil runs. Soil loss curves of previous work[11] show that erosion decreased toward the end of runs, with increased wetting.

A further comparison of the effect of supported mulch with surface mulch may be made in the last two lines in the lower portion of Table 1. Here the two types of mulch were placed over broken surface plots. Erosion and run-off were much the same whether the mulch was on the surface or supported.

It is appreciated that a greater intensity of water application, longer duration of application, a larger drop size (Laws[7] found that a 50 per cent increase in drop size, with drop velocity constant, resulted in a tenfold increase in soil concentration in run-off solutions of low density), different soil, or longer slope length, particularly the latter, might change the picture presented by these data.

All of the underlying implications of this study cannot be discussed fully here. Suffice it to say that although little is known of the relationship of overland flow (particularly laminar flow) and erosion, it is generally accepted that a definite relationship exists. Borst and Woodburn[11] have reported increased erosion accompanying slope-induced, increased velocity of run-off. It is obvious that any such relationship is based on availability of soil to be carried. It is generally thought that velocity provides its own load. Under certain conditions this is true. Conditions will vary with velocity, type of flow, and soil resistance.

Most velocity-erosion studies, however, have been made where drop impact was also active. It would seem that the relationship studied was an impact plus velocity-erosion relationship, and that impact sometimes may be the chief "availability factor". Obviously, with drop impact and without run-off transportive velocity sufficient to carry soil, there would be no erosion; so velocity is always a co-partner active in the dynamics of the erosion process.

That rain-drop impact may be a more important erosion factor than overland flow is borne out by the serious erosion caused by intense summer rains, as compared to winter rains[2,9]. Horton[5], summarizing the work of Lenard, Defant, Bentley, and others, states that drop size is closely related to intensity and, in general, the largest drop sizes occur in the most intense rains.

Effect of Surface Preparation on Erosion and Run-off. In the 1940 tests a somewhat surprising difference in erosion was found between runs on crusted or sealed bare plots and those cultivated lightly. These results suggested further studies along this line.

Three surface conditions were compared (Fig. 1). The first was that produced by hoeing and raking when the soil was at optimum moisture content. Under this condition, the plot surface broke up in fine granular form and may be said to have been ideally friable. Soil moisture in the upper 2 in was approximately 16 per cent (Table 2). The plots were hoed 2 in deep and raked smooth. The surface was then like a well-prepared garden with few small clods remaining.

The second surface condition was produced by hoeing the plots when the surface was dry. After cultivation, the plots were allowed to dry still further before the final raking so that at the time of the tests the surface was dry and dusty (upper 2 in averaged 7 per cent moisture).

The third surface condition was cloddy. Plots previously cultivated, and that had been crusted by rain application, were broken with a hoe when the soil was damp.

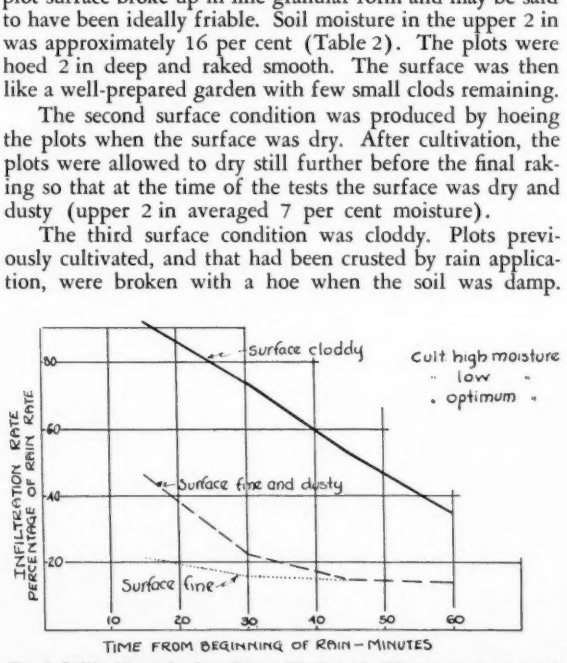

Fig. 1 Infiltration rate for plots cultivated at different moisture levels and to different degrees of fineness

The soil moisture content was 22 to 23 per cent in the upper 2 in. The soil was not wet enough to puddle nor would it make a mud ball when pressed in the hand. The clods produced by this procedure were allowed to dry until the upper 2 in of soil was at about 17 per cent moisture, at which time the clods were broken to some extent by a light raking.

Artificial rain was applied for 1 hr at approximately 2.20 in per hr, for all tests. The results of the tests of these three conditions are presented in Table 2 and Fig. 1.

It is of interest that the highest run-off and greatest erosion came from the plot prepared at optimum soil-moisture content. The run-off percentage from these plots was nearly as high as that from uncultivated sealed plots and erosion exceeded that from the uncultivated plots (Table 1). Apparently soil in this condition seals rapidly.

The run-off from the dry, dusty plots was somewhat lower than from the plots cultivated at optimum moisture content, and soil loss was only about 60 per cent of that from the optimum moisture content plots. Some reduction in run-off was expected since the dry surface would have a higher initial infiltration rate. The run-off from plots cultivated at optimum moisture content carried 3.6 lb of soil per cu ft, while that from the dusty plots carried only 2.6 lb.

The run-off from the cloddy plots for three runs averaged only 25.5 per cent. On two of them it was less than 19 per cent. Erosion was 2.4 tons per acre, as compared with 12 tons per acre from the optimum moisture-content plots and 7 tons per acre from the dusty plots. Density of run-off from the cloddy cultivation was 2.3 lb per cu ft.

Infiltration curves from these three series of runs are shown in Fig. 1. Initial infiltration was higher on the dusty plots than on the optimum moisture content plots, probably because of the low soil moisture content of the former. At the end of 60 min, however, the two treatments were performing much the same. Initial infiltration on the cloddy plots was high, quite similar to that on the straw-mulched, cultivated plots in the 1940 tests. Infiltration decreased rapidly, however, but did not reach the low rate of the other two conditions within the time period of test.

Depression storage, calculated according to Horton[6], averaged 0.08 in on the optimum moisture plots, whereas on the cloddy plots it averaged 0.26 in. Increased depression storage materially lessened run-off. It would seem that an important factor in the test was the erosion resistance of the clods. That they eventually partially slacked and that dispersed soil particles lowered the permeability of the surface layer, is indicated by the fact that the decrease in the infiltration rate was more rapid (Fig. 1) than that expected from an increase in soil moisture.

Previous studies have shown that soil surface condition materially influences run-off. These tests bring out the fact that surface condition also affects erosion losses to nearly the same degree.

It is appreciated that under practical conditions, the timing of tillage is governed to a considerable degree by convenience and opportunity rather than moisture content. Obviously crop responses to tillage methods and soil-moisture relationship must not be overlooked. Studies combining the effect of tillage on both responses of crops and soil conservation will be made in the future.

SUMMARY

Previous studies showed that a straw mulch at 2 tons an acre applied to a cultivated surface, controlled erosion and run-off rather effectively. The mulch applied to a soil surface that had been compacted and "sealed" by rains, controlled erosion, but did not greatly affect run-off.

The present study was designed to investigate the mechanics of the action of mulches in controlling erosion and to determine the relative importance of rain-drop impact and overland flow.

It was found that approximately the same degree of erosion control was afforded by mulches supported 1 in above a sealed plot as on the surface. It was therefore concluded that interference with overland flow when plots were surface mulched, was not of great importance in curtailing soil loss. Elimination of rain-drop impact, with its destructive effect on the soil surface, rather than the reduction of overland flow velocity appeared to be the major contribution of the mulch.

Further evidence of the potent effect of drop impact is disclosed when supported mulch was quickly removed during a run. Soil concentration in the run-off increased sixfold.

Previous tests showed that cultivation may affect erosion from a bare surface. Further investigation of this point was made by preparing plots at three moisture levels — rather damp, dry, and optimum for fine cultivation.

The soil prepared at optimum moisture content sealed earlier than the others, suffered the greatest run-off, and the highest average soil loss. The dusty plots also had high run-off and soil loss. The average run-off from the three plots, cultivated damp and left cloddy, was only 25 per cent and erosion was about one-fifth of that from the plots cultivated at optimum moisture content.

Soil conserving tillage practices must be based on crop response, as well as upon their soil and water conserving value.

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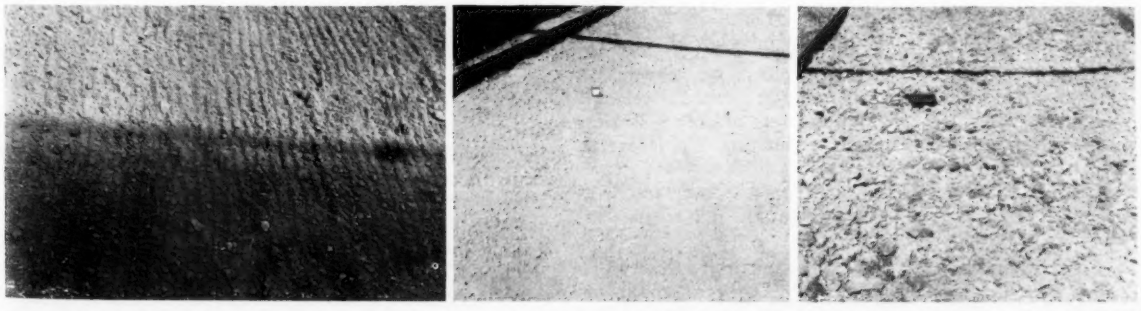

Fig. 2 (Left) Surface condition at optimum moisture content. (Center) Surface condition of a dry, dusty plot. (Right) Surface of a cloddy plot

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Discussion by Francis A. Post*

FIRST, I would like to commend Dr. Borst and Mr. Woodburn for making these studies. It seems to me that they offer an insight into some of the causes of erosion. An attempt has been made to study some of the limiting factors in the erosion process. In this paper run-off and erosion are used as indices to determine the effect of mulch on modification of the impact of rain drops and on overland flow over the soil surface. The use of a rainfall intensity of approximately 2.2 in per hr does not represent the maximum intensity reached by rains in the Zanesville, Ohio, area, but it is one of the higher intensities experienced.

The puddling effect on soil surfaces has been shown by numerous investigators to be highly significant. The degree of puddling may largely determine infiltration rates and run-off. The beating effect of rain drops is evidently the primary cause of surface puddling. Studies at the Coshocton (SCS) project have shown that the water held by imbibition and surface tension on straw mulch is only a minor subtraction from the hydrograph and is of the order of 0.01 in per 1,000 lb dry weight of plant residues.

Explanations of the effect of litter then can be made not on its water-holding ability, but on the buffer effect that it offers in reducing impact. Overland flow, although not measured, evidently is at a lower rate through mulch, as evidenced by the fact that rate of run-off was considerably modified.

Perhaps erosion opportunity might express the phenomenon that operates on bare-soil plots. Any obstruction that the surface may offer will necessarily reduce velocity. The fact was that the run-off water was of only a shallow depth on the surface. Probably at no time did it exceed 1/8 in depth. The effective part of the litter on the surface-mulched plot, as far as overland flow is concerned, was probably the small fraction of an inch in immediate contact with the surface of the soil.

Many litter studies at the Coshocton project lead us to believe that the number and surface area of the plant residue particles, and the extent to which they are anchored to the soil, are the important factors in determining the effect of mulches. In other words, 200 sq cm of surface, if it exists on a given area over 200 sq cm in one particle, is not nearly as effective as 10 particles each having a surface area of 20 sq cm. However, litter particles can be too small to be highly effective, but observations have shown that they must be reduced to very small sizes before this is true. These smaller sizes, however, might be considered as part of the soil itself. The effect of litter then is primarily dependent on the degree of coverage of the soil surface.

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BORST AND WOODBURN STUDIES SHOW LITTLE IMPOUNDING OF WATER BY RESIDUE DAMS

From the Borst and Woodburn paper it is seen that there was little impounding of water by residue dams, but that the effect of the mulch on overland flow was more that of maintenance of uniform distribution over the entire plot. Surface detention was greater on mulched plots than on the supported mulch. The supported-mulch plot is a unique method to determine the effect of drop impact versus overland flow and appears to be quite satisfactory. There was some evidence that a "water blanket" layer was of sufficient depth on the surface-mulched plot to absorb some of the impact of the rain drops. The fact that the soil loss was only slightly more from the supported-mulch plots than from the surface-mulched plots where the surface was broken on both the plots, leads us to believe that dispersion is practically simultaneous with erosion under the conditions studied. Drop size was larger under the supported mulch, but the drops did not fall far enough to establish much momentum. The slight increase in soil loss was probably due to the increase in drop size and possibly, to a certain extent, increase in rate of run-off. On corn fields and under other crops without natural litter the dispersion of the surface soil may be one of the principal causes of erosion by loosening the soil and making it available for erosion. Probably on longer slopes the carrying and cutting velocity would be dominant for the reason that rills and channels would develop. Under the conditions studied rills and channels did not develop to any great extent.

Some photographs taken at the Coshocton station have shown that a 2 mm diameter drop, falling from a height of 3½ ft and impacting on an individual wheat straw in a horizontal position, on a soil surface may be divided into 6 to 18 drops, ranging from 0.1 mm to 1 mm diameter. No doubt smaller particles were produced, which were not evidenced on the photograph. An area approximately 1 in in diameter received these smaller drops. Some of the water was retained on the surface of the straw and later delivered to the soil in a type of flow when sufficient water had accumulated, to be affected more by gravity than by surface tension. In other words, under a 2-ton straw mulch on the surface of the plot the rain may be delivered to the soil in at least three forms, drops, fine mist, and flow.

On the supported-mulch plot the water was delivered to the surface probably in two forms, drops and fine mist. The principal difference was that flow from the supported mulch was concentrated into drops larger than the initial rain drops falling on the surface of the mulch. The larger drops, however, were falling only a distance of 1 in and low velocity of fall equals low energy of impact. Contact flow from the mulch to the surface of the soil is not, at least in these experiments, the limiting factor in the prevention of pore clogging. As far as erosion is concerned, there is evidence that the form in which water comes in contact with the soil, whether *(Continued on page 24)*

Machinery in Peanut Production

By J. C. Oglesbee, Jr., and J. L. Shepherd
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PEANUTS are adapted to practically all of the soil types that are suitable for growing cotton, and the climatic conditions favorable for cotton culture are usually suitable for growing peanuts. It is said that peanuts will adapt themselves to a wider range of climate and soil conditions than almost any other crop. Since it is a tropical plant, the season required is 100 to 140 days without frost, with moderate rainfall during the growing period and an abundance of sunshine and relatively high temperatures. Best results are usually secured when normal annual rainfall is from 42 to 54 in.

Land preparation for peanuts is practically the same as for our other row crops. The land is usually turned very shallow and later well pulverized by disking and harrowing. In the cultivation of peanuts it is very important that all trash, sticks, and other foreign matter be thoroughly chopped and decayed so that they will not interfere with the early cultivation. Oftentimes the average small farmer is not equipped for doing a good job of turning this foreign matter under, and he resorts to the practice of raking and burning the sticks and other trash that tend to hinder cultivation on the peanuts. If adequate machinery were available to completely pulverize this material, it would eliminate burning these stalks and trash, thereby saving much humus in the soil, and also eliminate a good deal of hard labor in the preparation of the land for peanuts.

The most common practice in south Georgia is to plant both Runner and Spanish peanuts in a shallow furrow. Spanish peanuts are planted in hills about 6 in apart, and the Runner variety 10 to 14 in apart. The same planting equipment is used for peanuts that is used for corn and beans, in that seed peanuts can be handled in about the same manner as these other seed. The only change necessary is that a special plate is used for handling the nuts.

In a series of experiments that were carried on at the Georgia Coastal Plain Experiment Station, it was found that a 6-in drill spacing and 18 to 24-in row spacing gave the maximum yield per acre. When peanuts are interplanted with corn, velvet beans, or other crops, they are usually planted in alternate rows. Sometimes the rows of corn contain alternate hills of peanuts. These rows are usually spaced 3 to 4 ft apart, depending upon the fertility of the soil.

Very little fertilization is effective on peanuts, but they are able to use considerable residual plant food. Best results on the fertilization tests have been obtained by relatively light application (200 to 300 lb) of 2-10-4 or 2-10-6 commercial fertilizer applied at the time of planting in a band about 2 in to the side of the seed.

With large acreages of peanuts it is almost always necessary to use mill shelled nuts for seed. In the shelling process there is oftentimes internal damage to the seed that cannot be detected by mechanical and/or hand culling. Good sound seed are of great importance since specialists say low yields are almost always directly associated with poor stands. The seed costs are also relatively high, considering the value of the crop. Thirty to forty pounds of seed are required to an acre which usually costs from 10 to 12c per pound.

There is a definite need for a low cost peanut sheller that will do a good shelling job without a high percentage of injury to the seed nuts. This sheller should sell at a figure that would make it available on the average size farm.

Peanuts like many other crops are cultivated to keep down weeds and grasses, and at the same time to maintain a dust mulch for moisture conservation. Several cultivations are necessary in producing the peanut crop. During the early stages the conventional type weeder is used. If a hard beating rain falls shortly after planting, it is usually necessary to run the weeder diagonally across the rows to break the crust and allow the plants to come through. The weeding is usually continued to maintain a dust mulch and kill the small weeds and grasses until after the peanuts begin to bloom and the pegs begin to take form. This usually requires a period of approximately 6 weeks after planting. The weeding should take place often enough so that weeds and grasses will not get a start. This would usually be about every six to ten days. From this point cultivation is continued as long as necessary to control weeds by using ordinary shovel and sweep type plows. After the pegs on which the nuts are produced begin to form, cultivation is confined to the middle of the row in order not to disturb the young nuts. As soon as the nuts are formed at the end of these pegs, any close cultivation would injure the pegs and destroy the nuts.

Peanuts should be harvested before the vines are killed by frost. When to harvest the crop may be determined in two ways: first, by a slight yellowing of the foliage, and, second, by an examination of the pods. The tendency of many farmers has been to dig too early and before many of the peanuts are fully developed. On the other hand, if the harvesting is deferred too long the vines shed their leaves, and, in case of the Spanish variety, many kernels will be lost by sprouting, especially if a rainy period occurs. Harvesting the peanut crop is one that requires much hand labor and is one of the most laborious tasks found on the farm. The peanut harvesting season coincides generally with the picking of cotton. It is considered by many to be a definite handicap in the production of this crop. Much hand labor is required in picking cotton, and oftentimes there is a definite shortage of labor available for peanut stacking and picking.

The peanut is a nitrogen-forming plant and in digging should be loosened from the soil by means of a sharp instrument which will cut off most of the root system on which the nodules are borne. A number of diggers of the plow type that do this job in a fair manner are on the market. There are also special peanut points to be attached to the ordinary turning plow from which the moldboard has been removed. There are other types of peanut diggers, one of which consists of a sharpened, curved steel bar which is attached to a Georgia plow stock. Regular machine potato diggers with elevators have been found very satisfactory where the soil is reasonably dry and where the vine is small and free from grass. These machines not only lift the peanuts from the ground but also shake off the soil. The depth can be regulated so that the nuts can be cut off just deep enough to avoid loss of pods. Still the

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most common type of digger in use at present is the one-horse turning plow with alterations described above.

Some improved machinery is needed for digging the peanuts, particularly a type of digger that can be used with a small farm tractor. After the peanuts are plowed up, the vine is shaken by hand and left in small windrows where they should be sunned from 6 to 8 hr after pulling before being ready to stack. They are usually stacked on poles 6 to 8 ft high with cross arms to support the stack about 12 to 18 in off the ground. The nuts are placed next to the pole with the vines on the outside to protect the nuts from weather damage, and the stacks are covered with straw or dried crab grass. Sometimes, particularly with the Runner variety, the side-delivery rake is used for shaking and windrowing. When this method is used, however, it is impossible to place the nuts uniformly around stack poles, which often results in weather damage to the nuts.

Peanuts that are intended for market are left in the curing stacks for a period of 3 to 6 weeks before being picked from the vines. Peanuts cure very slowly in the stacks, and if picked from the vines too soon, the nuts have a tendency to shrivel and there is considerable danger of damage by molding. The commercial crop in Georgia is usually picked during October and November and practically always moved directly from the picking or threshing machine to the crushing or shelling plant where they are stored until used.

THE CAPACITY OF PEANUT-PICKING MACHINES AVERAGES ABOUT 3 TONS PER DAY

Two types of picking machines are now on the market, one working on the principle of a cylinder grain thresher and the other provided with a wire mesh, over which the peanuts are drawn in such a manner that they fall through and are pulled from the vines. The capacity of peanut-picking machines depends upon the make of machine and the condition of the peanuts, about 3 tons per day being an average. In addition to removing the pods from the vines, the machines have special facilities for cleaning them and taking off the small stems. While some of the picking machines work very satisfactorily, some of them oftentimes leave a great many sticks and stems with the nuts, thereby considerably lowering the grade.

The peanut picker is usually set up at a convenient point near the center of the field to avoid loss of time in hauling the stack a long distance. In very large fields it may be advisable to make more than one setting. The entire stack, pole and all, is brought to the picker whereby none of the peanuts are wasted by this method as would be the case if the vines were removed from the poles in the field. Since the stacks are small and the poles are not usually set very deep in the ground, it is an easy matter for two men to load the small stacks on low-wheeled wagons. After the stacks reach the picking machine, the poles are drawn out and thrown to one side. In some sections of the state, special drags or carts are employed for hauling the stacks to the picker.

Short cuts in harvesting the peanut crop at present appear to be out of the question since they must be thoroughly cured before they can be satisfactorily picked. This would discourage or eliminate short cuts in harvesting machinery, such as artificial drying and the combine method of harvesting. It is not believed that any research work has been done to determine the chemical action that takes place in the peanut during the curing period, but it is thought that there are some changes from sugars to starches, or vice versa, that would require a considerable amount of time, hence making it difficult to hasten the curing process.

The Effect of Mulching and Methods of Cultivation on Run-off and Erosion

(Continued from page 22)

it be small drops, large drops, contact flow from vegetation, or overland flow of the several types, is important principally because of the energy relationships of the water coming in contact with the soil surface.

The upward components of force exerted by the splash from rain drops impacting on the soil surface may be sufficient, in cases where there is a small amount of surface detention, to bring into suspension the greater part of the soil leaving the plot area. The effect of clod mulch can be explained partly by the fact that the clods themselves presented a supersurface that may have absorbed some of the initial impact of the drops and delivered the water to the soil mass at a much lower velocity. In the case of the dust mulch, it is possible that the dust consisted of fine water-stable aggregates. The super-surface created by the dust mulch did not give as good control of run-off and soil loss as did the clod mulch, but gave much better control than did the optimum moisture plots. It is interesting to note that the clod mulch remained stable as long as it did. During the run there was some evidence of partial slaking of the clods.

The dust mulch showed the two decided breaks in the infiltration curve. A break in the infiltration curve of the "optimum moisture" plot coincided with a break in the dust mulch curve. The break points may indicate clogging of the surface pores. Some reduction in infiltration would be expected because of soil moisture increase. To what degree the clods and the dust were water stable seemed to control the infiltration rate in these experiments.

CONDITIONS WHICH PROVIDED RUN-OFF ALSO PROVIDED SOIL AVAILABLE FOR EROSION

Attention should be called to the consistency of the results from the plots cultivated at different moisture levels. The soil loss was significant in all cases and materially increased with the volume of run-off in each case. In other words, the conditions which provided run-off in these experiments also provided soil available for erosion. Numerous records of pasture watersheds show that large volumes of run-off have been due to high intensity rains or to the fact that the reservoir capacity of the soil has been satisfied.

In all cases the runs provided water sufficient only to partially satisfy the reservoir capacity of these soils. Work which F. R. Dreibelbis and F. A. Post (An Inventory of Soil Water Relationships on Woodland, Pasture, and Cultivated Soils) have done has shown that the reservoir capacity of Muskingum silt loam to the 40-in depth is of the order of 8 in active soil water or 15 in total water. This of course includes gravitational water held in the non-capillary pore spaces. All the plot experiments were conducted on soils which did not have their reservoir capacity satisfied. No dependence was made on the ability of the lower soil horizons to transmit water.

It is very possible that on longer slopes or with a higher rain intensity or on a soil whose reservoir capacity has been more nearly satisfied, that the overland flow characteristics may be materially changed, especially in the lower reaches of a slope. Supersurfaces consisting of plant residues may again materially change these characteristics of overland flow.

The question of what degree of impact control the various types of supersurfaces above the soil mass can give under known impacts and drop sizes of rainfall is one on which much study in the future should be directed

WINTER VITAMINS . . . *on the way!*

Freshly-grown, vitamin-rich vegetables—made available at moderate prices throughout the country, throughout the winter—are transforming America's eating habits.

Enterprising men, riding modern, Diesel-powered ideas, in areas where soil and climate cooperate, have effected this transformation with "Time-Table" Farming!

The pictures here show February carrot harvesting and packing for K. K. Sharp, Holtville, California, one of Imperial Valley's largest Grower-Shippers.

He plants a part of his carrot acreage every week from September 1 to New Year's Day—has to hit "on the nose" his soil-preparation, seeding and harvesting, to produce uniform crop, keep the shipments timed, keep the 500-600 person crew busy.

"Fifteen years of using this make of equipment exclusively show what I think about the quality and dependability of 'Caterpillar' track-type Tractors for heavy work that has to be done on time," states Mr. Sharp. "They stay on the job."

Apparently, a good many of Mr. Sharp's fellow growers share his sentiments. *For more than 75% of the heavy-duty pulling tractors at work in the Imperial Valley are "Caterpillar" Diesel Tractors!*

CATERPILLAR TRACTOR CO., PEORIA, ILL.

CATERPILLAR
REG. U. S. PAT. OFF
Diesel

DIESEL ENGINES • TRACK-TYPE TRACTORS • TERRACERS

NEWS

A.S.A.E. Meetings Calendar

February 4 - 6—Southern Section, Gayoso Hotel, Memphis, Tenn.

April 3 - 4—Southwest Section, Texarkana, Texas.

June 29 - July 1—Annual Meeting, Hotel Schroeder, Milwaukee.

Nominations for 1942-43 A.S.A.E. Officers

THE Nominating Committee of the American Society of Agricultural Engineers, consisting of R. U. Blasingame (chairman), T. E. Hienton, and H. H. Sunderlin, have placed in nomination the following members of the Society as candidates for the various offices to be filled at the next annual election of officers:

For President

H. B. WALKER, head, agricultural engineering division, University of California

For Councilor

E. C. EASTER, agricultural engineer, Alabama Power Co.

W. E. MEEK, special representative, tillage and seeding machine sales, International Harvester Co.

For Councilor

B. P. HESS, manager, rural electrification, Westinghouse Electric & Manufacturing Co.

C. G. KRIEGER, agricultural engineer, Ethyl Gasoline Corp.

Nominating Committee

E. D. ANDERSON, Republic Steel Corporation

D. G. CARTER, University of Illinois

I. D. MAYER, Purdue University

A. J. SCHWANTES, University of Minnesota

A. P. YERKES, International Harvester Co.

W. L. ZINK, Sears, Roebuck and Co.

The by-laws of the Society provide that by March 1 of each year the Secretary of the Society shall mail each member entitled to vote a ballot stating the names of the candidates for the elective offices to be filled at the next election.

Program for Southern Section Meeting

THE Southern Section of the American Society of Agricultural Engineers will hold its yearly meeting February 4, 5, and 6, 1942, at Memphis, Tennessee, in conjunction with the annual convention of the Association of Southern Agricultural Workers. All sessions will be held in the ball room of the Gayoso Hotel.

A very interesting program has been arranged by the officers of the Section constituting the program committee, including Section Chairman C. J. Hurd, chief, agricultural engineering development division, Tennessee Valley Authority; Vice-Chairman Ray Crow, engineer, sales promotion division, Tennessee Coal, Iron, and Railroad Co., and Secretary W. N. Danner, Jr., professor of agricultural engineering, University of Georgia.

The first session of the meeting will start at 2:00 p.m., Wednesday, February 4. It will be a joint session with the Soil Conservation Section of the A.S.A.W., and will be devoted to the general subject of soil and water conservation, including drainage. The following papers are scheduled for this session. "The Development of Water Disposal Systems," by W. A. Weld, associate agricultural engineer, U. S. Soil Conservation Service; "Some Indicated Benefits of Rotating Cotton with Close Growing Crops," by J. R. Carreker, associate agricultural engineer, S.C.S.; "The Effectiveness of Grazing in Maintaining Open Drainage Ditches," by Howard Matson, chief, regional engineering division, S.C.S.; "Farm Drainage," by Harry G. Edwards, associate drainage engineer, S.C.S., and "The Interrelation of Drainage and Soil Conservation Practices," by L. A. Jones, chief, division of drainage, S.C.S.

At the second session, to convene at 9:00 a.m. Thursday, February 5, the following program features are scheduled: "A Thrilling New Industry Challenging Agricultural Engineers," by Robert S. Snowden, Jr., vice-president, National Frozen Food Locker Assn.; "How Locker Refrigeration Benefits Farmers in Lee County, Mississippi," by R. G. Purnell, owner of Tupelo (Miss.) locker plant; "The Georgia Program for Providing Locker Refrigeration as a Community Enterprise," by L. M. Sheffer, state supervisor of agricultural education; "Training for the First Job," by Arthur W. Turner, agricultural advisor, International Harvester Co.; A Symposium on Farm Machinery Repair, led by C. E. Seitz, head of the agricultural engineering department, Virginia Polytechnic Institute, and participated in by representatives from the U.S.D.A., the colleges, and the farm machinery industry.

Following is the program for the fourth session of the meeting, at 2:00 p.m., Thursday, February 5: "The Importance of Good Housing to the Social, Moral, and Physical Development of the Family," by Dr. Carl Taylor, head, division of farm population and rural welfare, U. S. Bureau of Agricultural Economics, followed by a discussion from the agricultural engineering viewpoint by R. H. Driftmier of the University of Georgia, and from the home economics viewpoint by Miss Jacqueline Hall, home demonstration agent, Shelby County, Tennessee; "Relation of Farm and Home Electrification," by Miss Maude Smith, home electrification specialist, and F. M. Hunter, rural electrification specialist, Mississippi State College; "Curing and Storage of Sweet Potatoes," by W. S. Anderson, head, agronomy department, Mississippi Agricultural Experiment Station, and E. T. Swink, assistant extension agricultural engineer, Virginia Polytechnice Institute; and "The Present Status of the Program for Determining the Complete Usage of the Sweet Potato Plant for Silage and other Types of Feed," by H. W. Bennett, associate agronomist, Mississippi Agricultural Experiment Station.

A new feature of the meeting this year will be a Section dinner scheduled to be held at the Claridge Hotel at 7:00 p.m., February 5, at which Wm. E. Meek will act as master of ceremonies. The address of the evening, entitled "So What", will be delivered by Geo. W. Kable, president of the A.S.A.E. The social program will be followed by reports of committees.

The last session of the meeting, at 9:00 a.m., Friday, February 6, will feature the following papers: "How Electricity and Machinery on the Farm can Contribute Most to the Agricultural Defense Program," by Harry L. Brown, general agent, U. S. Farm Credit Administration; "A Farm Machinery Program for Southern Farms," by I. F. Reed, associate agricultural engineer, Farm Tillage Machinery Laboratory, U.S.D.A., with a discussion by J. C. Oglesbee, Jr., extension agricultural engineer for Georgia; "Feed and Food Preparation with Gas and Electric Power," by L. E. Hazen, head, agricultural engineering department of Oklahoma A. & M. College, and "Home Grinding for Nutrition," by Oscar W. Meier, head, cooperative education section, R.E.A.

Pacific Coast Section Meeting

THE 20th annual meeting of the Pacific Coast Section of the American Society of Agricultural Engineers and the 13th annual Farm Machinery Conference were held jointly, January 9 and 10, on the branch campus of the University of California at Davis. A.S.A.E. President Geo. W. Kable made a special trip to the Coast to attend the meeting, where he was the principal speaker at the joint dinner. Unfortunately copy for the program was not available in time for the information of members through these columns prior to the meeting.

Personals of A.S.A.E. Members

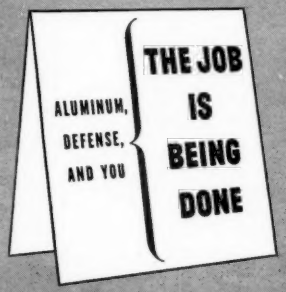
George E. Cubberly is now an assistant soil conservationist with the U. S. Soil Conservation Service. He is planning technician for the James River conservation district in Prince George County, Virginia.

J. W. Martin has been promoted from instructor to assistant professor of agricultural engineering, Kansas State College. He is also joint author with June Roberts of Extension Bulletin 87, entitled "Feed Grinding with Small Electric Motors," recently issued by that institution.

Howard T. Palmer has transferred from his position with the Soil Conservation Service to that of "equipment and inventory inspector" with the Farm Security Administration. His territory will cover the Northern Great Plains section of the country.

George M. Petersen has resigned as special research assistant in agricultural engineering at the University of Illinois, to accept a position as instructor in agricultural engineering at the University of Tennessee. *(News continued on page 28)*

ALUMINUM, THE FUTURE, AND YOU



RIGHT NOW OUR FACTORIES have only one interest: to make more Defense Aluminum than the world has ever seen before. Every resource we can muster is concentrated on that job.

WHEN AMERICA HAS WON THROUGH to make the world safe for our children to live in . . . the saying is: What a lot of aluminum is going to be available for everybody.

THE REAL POINT TO PONDER is how to get set to make that deluge of light metal work for you. In the kind of world we're going to have, sure as fate, the man who fails to call, *now,* on every resource at his command is going to be left at the post.

WE'VE COINED A WORD:

IMAGINEERING. It's the fine art of deciding where you go from here. It's the act of thinking out what you are going to face, and doing something about it now. *Imagination* plus *engineering* is a formula for the future you're going to hear more about.

A MAN CAN be producing for Defense at top speed and be imagineering at one and the same time. In fact, the more he is devoted to Defense now, the more he needs imagineering for ***THE DAY WHEN.***

OBVIOUSLY, you can imagineer with steel, copper, glass, zinc, plastics, or what have you. We hope you will, because the world is going to need better use of all materials than it ever saw before.

THE CLOSER YOU GET TO FUNDAMENTALS the more quickly you must decide that the great need is going to be for the very things Alcoa Aluminum does best: Lightness with strength, resistance to corrosion, reflectivity, workability and all the rest of its powers all wrapped up in a low-cost package full of unlimited possibilities for you, personally, in your business.

TWO HEADS ARE BETTER THAN ONE. Already, many an industry, many a company, has called us into an imagineering session. We've seen things projected that will make news when the curtain can be lifted. Usually we've been able to help with some imagineering of our own.

DOES THIS SUGGEST ACTION? WE HOPE SO.

Aluminum Company of America, Pittsburgh, Penn.

ALCOA ALUMINUM

Does Fencing Pay?

IT has been said that one-third of our farmers just get by, one-third prosper now and then, and one-third are well-to-do. Just why one man should be able to obtain greater net returns from the soil without draining its fertility, is largely a matter of management. Perhaps no single factor plays a greater part in good management than proper fencing and intelligent pasturing of land.

Proper fencing pays returns in many ways — year after year. In fully fenced fields; the farmer can let hogs salvage stray ears after corn picking, or by hogging-down save picking costs and add fertility to his soil. Sheep can make much of their living from field gleanings, and also help control weeds. Permanent pastures can be completely rested and given a chance to restore themselves while stock is grazed on cover crops or temporary pastures. Special summer pastures can save regular pastures and prevent the summer slump in milk flow. Legumes can be used more largely for soil-building and conservation because they can be pastured profitably.

The year after year value of a fence investment will depend of course on the life of the fence itself and how it is erected. Continental has developed the "Flame-Sealed" process of zinc coating wire which contributes greatly to the rust-resisting qualities of all Continental Fence. Continental Fence is made of special analysis copper-bearing steel. There are 15 different styles to meet every fence requirement.

CONTINENTAL STEEL CORP., Kokomo, Indiana
Plants at Canton, Kokomo, Indianapolis

CONTINENTAL SUPERIOR STEEL
CONTINENTAL STEEL CORPORATION
15 Types of Farm Fence Posts, Gates, Barb Wire
14 Styles of Steel Roofing and Siding, and Fittings
Nails Staples, Lawn Fence, Wire Products

Personals of A.S.A.E. Members

(Continued from page 26)

June Roberts, investigator in farm electrification, Washington Agricultural Experiment Station, is one of the authors of Bulletin No. 404, entitled "The All-Electric Greenhouse," recently issued by that station.

Lawrence H. Skromme has severed his connections with the engineering department of Goodyear Tire & Rubber Co., to accept appointment as design engineer, Ferguson-Sherman Mfg. Corp., Dearborn, Mich. His new work will include design and development work on tractors and other machinery.

Harold D. White has received appointment as assistant professor in agricultural engineering at the University of Georgia. He is a graduate in agricultural engineering from that institution. He received his master's degree from Iowa State College, and for the past three years he has been associated with the latter institution during which time he has completed major requirements for a doctor's degree.

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Robert A. Breckenridge, junior agricultural engineer, soil and moisture conservation division, Bureau of Reclamation, U. S. Department of Agriculture. (Mail) 909 Chicago St., Caldwell, Ida.

Max Chandler, farm sales and service, Detroit Edison Co. (Mail) RR No. 1, Monroe, Mich.

Dan H. Daubert, research division, J. I. Case Co., Racine, Wis.

William M. Hardy, state coordinator, Soil Conservation Service, U. S. Department of Agriculture. (Mail) Box 419, Nashville, Tenn.

Anson Hayes, director of research laboratories, American Rolling Mill Co., Middletown, Ohio. (Mail) 311 Stanley St.

Donald L. Hitch, assistant to specialist in soils and irrigation, agricultural extension service, University of Arizona, Tucson, Ariz.

Vilas E. Rice, research associate, State Rural Electrification Committee, 220 Centennial Bldg., Springfield, Ill.

Don Royse, special representative in charge of farm marketing, The Texas Co. (Mail) 714 S. New St., Champaign, Ill.

Clarence E. Stevens, Jr., instructor in agricultural mechanics, University of Delaware, Newark, Del. (Mail) 1-A Academy Apts.

TRANSFER OF GRADE

Donald C. Wiggins, agricultural engineer, Carnegie-Illinois Steel Corp. (Mail) Apt. B-9, Brentshire Village, Pyramid Drive, Brentwood, Pa.

Student Branch News

Active Branches. During the school year 1940-41 there were 28 active student branches of the American Society of Agricultural Engineers, situated in the land-grant colleges and universities of 27 states of the United States and one province of Canada, the largest number in the history of the Society. The membership lists and branch dues for the current school year of all twenty-eight of these branches were received prior to January, and following is the order in which they were received: Georgia, Florida, Minnesota, Texas, Kansas, Michigan, Illinois, Iowa, Ohio, Clemson (S.C.), South Dakota, Utah, Missouri, North Dakota, Pennsylvania, Idaho, Nebraska, North Carolina, Tennessee, Alabama, Louisiana, Oregon, Saskatchewan, Mississippi, Virginia, Washington, Oklahoma, and Wisconsin.

TEXAS

By W. T. Hall, Scribe

THE Texas Student Branch of A.S.A.E. at the A. and M. College of Texas has been having some outstanding programs and activities during the past two months. The seniors took their annual fall inspection trip to Dallas on October 16 and 17. They spent the first day at the state fair grounds where they saw and studied the farm machinery that was on display. The second day was spent visiting several farm machinery branch houses and manufacturing plants. When they were through on Friday, October 17, they went to Ft. Worth to join the remainder of the corps, 6,500 strong, to see the Texas A. and M. football team defeat Texas Christian University. *(Continued on page 30)*

The FARMALL on Your Farm will NOT be Called for Military Service

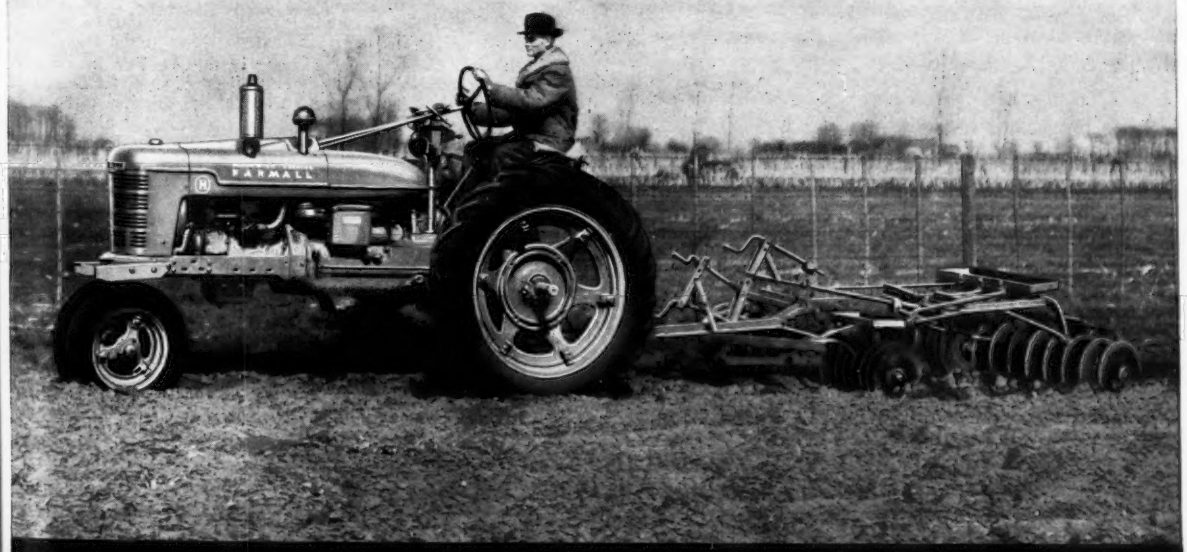
THE handwriting is on the wall, plain for all to read. Young men working on the farm today may be off to camp tomorrow. Production of new farm machines to take their place will, in some degree, be limited by production of war machines.

But of this one thing you may be sure: *the Farmall tractors, at work on farms, won't be called away for military service!*

These great power-partners are available now, and they'll handle the big jobs on any farm for years to come. As each season rolls around, Farmall tractors will be *in there working*—with greater efficiency than any other farm power. These tractors lead all others. They excel in handling all jobs from plowing, planting and cultivating to bringing in the harvest and teaming up with other machines on year-'round belt work.

That is why so many farmers are *buying Farmalls now.* They recognize in these tractors a constant source of aid and protection for themselves and their families. *With the strength of many men a new Farmall gives added security against any winds that blow.*

INTERNATIONAL HARVESTER COMPANY
180 North Michigan Avenue Chicago, Illinois



THE FARMALL FAMILY
Power and Equipment for All Farm Needs

KNOWING SHEET METALS IS YOUR JOB—AND OURS

You can greatly increase the efficiency and service of farm equipment and buildings by using *special-quality* sheet metals such as these. . . .

One that has proved its value is ARMCO ZINCGRIP. It has a tough hide of zinc that will not peel or flake when formed severely by the manufacturer. This gives complete zinc protection to the metal base. ZINCGRIP is ideal for stock tanks, poultry equipment and formed parts of grain drills, hammermills and other farm machinery.

ARMCO Ingot Iron was the first durable low-cost metal created for farm uses. It has the longest service record of any inexpensive iron or steel sheets and makes silos, grain bins and other farm buildings stand up longer.

Still another metal, ARMCO Galvanized PAINTGRIP, has a special coating that takes and preserves paint. It is ideal for combines, corn pickers and many other kinds of painted farm equipment.

• Ask us for informative bulletins on any of these *special-quality* ARMCO metals. When writing please mention your company or affiliation. The American Rolling Mill Company, 261 Curtis Street, Middletown, Ohio.

STUDENT BRANCH NEWS

(Continued from page 28)

The Branch was very fortunate to have at one of its earlier meetings President George W. Kable of A.S.A.E., who gave a very interesting talk to the group.

One of our recent meetings was a discussion and demonstration on fluorescent lighting for the farm, by J. N. Brannan of the Texas Power and Light Co. This meeting was held in connection with the annual rural electrification short course sponsored by the agricultural engineering department.

For the last meeting in October, we had as guests several representatives of the John Deere Plow Co. of Dallas who showed pictures on farm machinery. Each year we count on one program by John Deere.

In order to stimulate greater interest in the activities of the Branch, a committee was appointed to prepare a merit system whereby the outstanding members of the Branch might be selected to receive some special recognition. A point system was set up so that the number of points obtained will be a measure of the student's activities in the Branch. The requirements for obtaining the necessary number of points are such that every student has an opportunity to qualify. However, these requirements are rigid enough so that it is expected only a relatively small percentage of those graduating will accumulate the necessary points, and this will require more than average effort for a period of three to four years. The system set up by the committee was adopted by the Branch, but the nature of the award will be decided upon at a later meeting.

ALABAMA

By Jack E. Conniff, Scribe

THE Alabama Student Branch of A.S.A.E. at the Alabama Polytechnic Institute had its first meeting September 29. The president, Fred Curtis, opened the meeting with a speech welcoming the freshmen and outlining the purpose and accomplishments of the club. Dr. J. H. Neal, head of the department, invited the club members and faculty to his home for a social to get the freshmen, upperclassmen, and faculty members better acquainted.

There have been several interesting talks made at the meetings this year, one given by the latest addition to the faculty, Prof. Harry B. Pfost, on his experience while working with the REA. Another very interesting talk was made by Mr. A. W. Cooper on his trip to Washington, D. C., to attend the American Society of Agronomy and Soil Science convention. Two other interesting talks were given by club members, J. A. Rogers and O. D. Alsobrook, Jr., on their trip to the Industry Seminar, sponsored by the American Society of Agricultural Engineers. Their talks included a description of the various farm equipment manufacturing plants along with a few of their experiences while on the trip.

The club planned to participate in the Ag Fair by sponsoring several interesting and educational exhibits. Committees had been appointed to build the exhibits, but the Fair had to be postponed due to the OPM's ruling that no current could be used. It will, however, be held at a later date. The Ag Fair is staged annually by the Ag Club with the cooperation of several other student organizations. The club took an active part in the Engineers' Carnival by sponsoring a dance which ranked high among the various concessions as a profit-making attraction. The profits coming from the Carnival were turned over to the Engineering Council by all of the organizations participating. This fund will be used to cover the expenses of Engineers' Day to be held next May.

Because of its accomplishments so far, and the plans already made for the future, the Alabama Student Branch is looking forward to a very successful year.

The officers for this semester are Fred Curtis, president; Herbert Fleming, vice-president; Aubrey Pettis, secretary; Mark Skelton, treasurer; Jack Conniff, scribe; and Prof. F. A. Kummer, faculty advisor.

GEORGIA

By T. F. Lumsden, Scribe

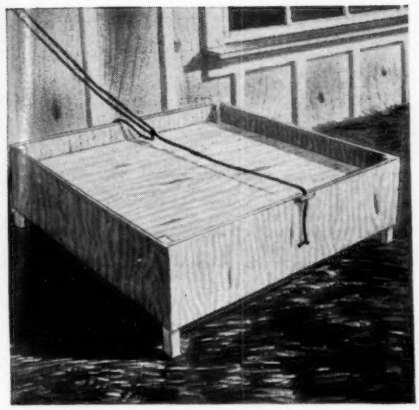
THE Georgia Student Branch of A.S.A.E. held its regular biweekly meeting Monday evening, November 24. All participants on the program were freshmen, except W. D. Kenny, a senior in charge. Each freshman had been assigned and asked to explain some part of the constitution of the Georgia Branch or the national A.S.A.E. constitution. The program was a successful one. Each freshman knew his part well and presented it like a veteran. This program was suggested by Prof. W. N. Danner, faculty adviser of our Branch, the purpose of the program being to stimulate more interest in the club. *(Continued on page 32)*

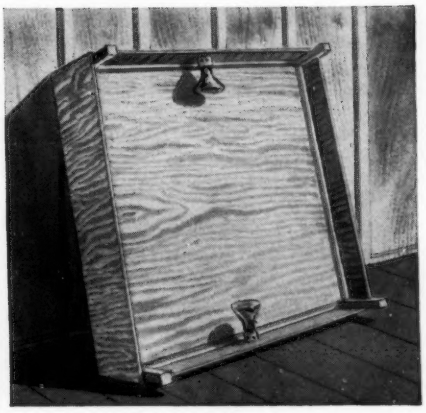
FOR VICTORY...

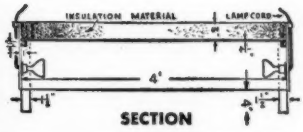
Speed agricultural production with DOUGLAS FIR PLYWOOD

☆ ☆ ☆ ☆ ☆ ☆

Use this engineered lumber for rapidly fabricated, economical structures and equipment . . . and help stimulate the increase in dairy, swine and poultry products this country vitally needs!







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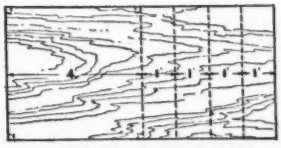


PANEL CUTTING LAYOUT

This inexpensive, home-made radiant heat floor hover (Bi-Monthly Bulletin, Ohio Agricultural Experiment Station, Vol. XXVI, No. 209, Mar.-Apr. '41, pages 48-52) is an excellent example of the simple designing and fabrication made possible by use of Douglas Fir Plywood.

Adaptable to farmers' needs!

Douglas Fir Plywood is a material farmers like to use . . . and now when thousands of farmers are having to change their production as their part of national defense, this "modern miracle in wood" can be of more service to them than ever before.

Douglas Fir Plywood is available at any retail lumber dealer. The large, light-weight, puncture-proof panels work up quickly with ordinary carpentry tools. There is a minimum of waste because even the smallest scraps can be salvaged for bracing and other purposes. Another saving is that every panel is full-dimension: every 4'x8' panel actually covers 32 square feet.

Ideal for glued construction

Douglas Fir Plywood holds nails and screws close to the edge without splitting or breaking. It is the most logical material to be used in glued construction, which tremendously increases the strength and rigidity of a structure and permits simplified framing. Douglas Fir Plywood builds tight walls and reduces infiltration to a negligible amount. It has excellent insulating characteristics.

Plywood is kick-proof

Structures built of Douglas Fir Plywood are sturdy and durable under repeated handling and for long periods of use. Because of great strength in all directions and superior nail-holding qualities, hovers, shelters or portable plywood structures do not rack out of shape. Animals cannot kick or peck through plywood walls, either. And the smooth surfaces of plywood panels are clean and sanitary.

For greatest economy, always specify the exact type or grade of Douglas Fir Plywood that should be used. In most farm work intended for interior use, like the hover shown above, the Moisture-Resistant type of Douglas Fir Plywood in a Plywall (So1S) grade—or the slightly thicker Plyscord (utility face veneer, unsanded)—is proper. But for all permanent outdoor uses, the Exterior type of Douglas Fir Plywood, made with a water-proof bond and edge stamped EXT-DFPA, should be specified.

Write for helpful data

The Douglas Fir Plywood Association welcomes correspondence with agricultural engineers and rural architects on problems relating to the use of plywood in agricultural production structures. Douglas Fir Plywood Association, Tacoma, Washington.

GENUINE DOUGLAS FIR PLYFORM Concrete Form Panel D.F.P.A. INSPECTED

GENUINE PLYWALL Douglas Fir Plywood WALLBOARD D.F.P.A. INSPECTED

SPECIFY DOUGLAS FIR PLYWOOD BY THESE "GRADE TRADE-MARKS"

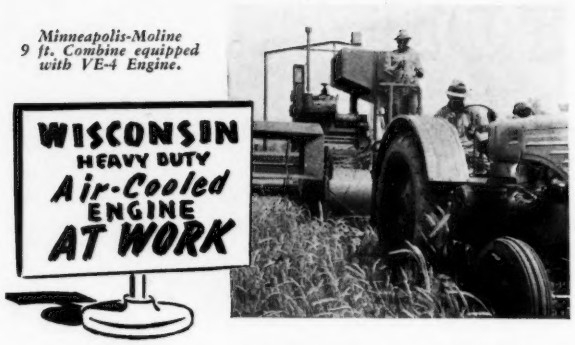
PLYPANEL D.F.P.A.

EXT.-D.F.P.A.

GENUINE PLYSCORD SHEATHING D.F.P.A.

DOUGLAS FIR PLYWOOD Real Lumber MADE LARGER, LIGHTER SPLIT-PROOF STRONGER

Minneapolis-Moline 9 ft. Combine equipped with VE-4 Engine.



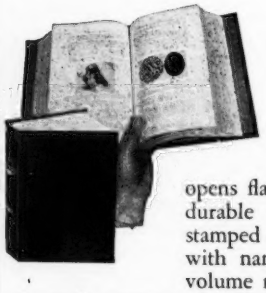
Stepping up and maintaining work schedules during these days of high pressure production in all lines, requires equipment of maximum dependability and efficiency.

Because Wisconsin Engines (1 to 35 hp.) are built for *heavy-duty* service; because they are *air-cooled;* because they are compact in design; extremely light in weight; equipped with weather-sealed outside magneto with impulse coupling for quick starting in any weather; because they run on Timken roller bearings . . . Wisconsin Engines AT WORK today, are increasing productive capacity wherever they are in use.

MOST POWER Per POUND

WISCONSIN MOTOR Corporation
MILWAUKEE, WISCONSIN, U. S. A.
World's Largest Builders of Heavy-Duty Air-Cooled Engines

A Handsome, Permanent Binder
for AGRICULTURAL ENGINEERING



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Mail postpaid.....binders for Agricultural Engineering for years.....
Will remit in 10 days or return binders collect.

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Address.....

City.....State.....

STUDENT BRANCH NEWS

(Continued from page 30)

On Friday evening, December 12, the Branch gave a banquet in honor of Prof. U. H. Davenport. Prof. Davenport is the oldest faculty member in the agricultural engineering department of the University of Georgia. He is known to students as "Fess" Davenport, and many of his friends, nearer his own age call him "Davie". "Fess" has been an instructor in the agricultural engineering department ever since there was one. He teaches the more technical subjects, namely, mechanics, electrical engineering, etc., the ones that are hard and easy to flunk. But pass or flunk the students' love and respect for "Fess" Davenport never changes.

The banquet was held at the new Ag Hill dining hall. A three-course dinner was served, the main course being turkey with all the trimmings. The program consisted of C. B. Seckinger, master of ceremonies; Prof. U. H. Davenport, "Reminiscences of the University"; Cecil Mize, "Dedication and presentation of honor key"; W. D. Kenny, "Farewell to Mr. Shepherd", who leaves for army duty next quarter; Prof. R. H. Driftmier, "Welcome to Mr. Kinard", who is a new faculty member in the department. Much of the credit is given to Cecil and Clyde Mize for making this banquet a successful one.

At the last meeting officers were elected for the winter quarter. They are as follows: Clyde Mize, president; Harold King, vice-president; W. A. Strauss, secretary; Cecil Mize, scribe.

EMPLOYMENT BULLETIN

The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted," or apply for positions under "Positions Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted." Any notice in this bulletin will be inserted once and will thereafter be discontinued, unless additional insertions are requested. There is no charge for notices published in this bulletin. Requests for insertions should be addressed to ASAE, St. Joseph, Michigan.

POSITIONS OPEN

AGRICULTURAL ENGINEER wanted for farm structures research work in the agricultural experiment station of a southeastern college. Only a man with some research experience and not subject to immediate military service will be considered. Work will be primarily concerned with storage buildings. Good fundamental training with good scholastic records necessary. Salary up to $2,700 according to qualifications. PO-134

POSITIONS WANTED

AGRICULTURAL ENGINEER, also farm and supply manager, has had 20 years' experience in agricultural pursuits as manager of large farming enterprise and agricultural supply house, and as chief agricultural engineer of large irrigation development in the West. Has had technical training and practical experience in all phases of engineering and agricultural production, development, and marketing. Best of references. Forty-four years of age. Married. PW-341

AGRICULTURAL ENGINEER with 15 years' experience in the farm equipment industry; knows both farmer and tractor and implement industry in all sections of world; especially Canada and U.S.; advertising, public relations, editorial, camera, radio; can direct a complete service for dealers and factory; knows governmental and agricultural college officials; Farm Bureau; boys' and girls' clubs, livestock and special crop associations. Will locate anywhere the right firm or industry may wish. Have production records that speak. Personal portfolio mailed on request. PW-343

AGRICULTURAL ENGINEER desires employment offering larger opportunity. Ten years' experience in the electric utility industry and two years' experience as an assistant extension agricultural engineer. Good farm background. Particularly qualified to handle all phases of rural electrification, pump irrigation, and farm machinery. Capable of planning and conducting educational or promotional activities. Holds a state professional engineering certificate. Thirty-six years of age. Married. References on request. PW-344

AGRICULTURAL ENGINEER with B.S. degree from midwestern college (1938) and M.S. degree from southern college (1940), desires employment with the Soil Conservation Service, in a defense industry, or in other engineering work. Has 1½ years' experience as engineer with the U. S. Soil Conservation Service in the South and in the Pacific Northwest. Familiar with agriculture in most parts of the United States. Civil Service rating as junior engineer. Eligible for reappointment. Age 35. Married. PW-345

AGRICULTURAL ENGINEERING

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EDITORIAL

Chemurgy and Strategy

CURTAILMENT of supplies of ethyl alcohol available for civilian use, due to its need for munitions manufacture, and the reflection of that same need in the sugar rationing plan, both suggest that we may have been misguided in judging the fuel alcohol question entirely by technical and economic criteria. We now would be in a more comfortable position, as a nation at war, if we had a large alcohol productive capacity which could be diverted on short notice from fuel to defense.

This writer never has been enthusiastic about alcohol simply as a source of Btu's, and still doubts that it can become economic on that basis. However, its known value for improving octane rating, and the possibility that its utility in improving the combustion characteristics of hydrocarbons might be further enhanced by chemical transformation or by combination with other substances, seem to deserve more serious study than has yet been conducted or even contemplated.

If this is to be the long war that military experts predict, with outcome dependent more and more on the weight of munitions that can be manufactured, we no doubt shall arrive at the problems of peace with a plant capacity for ethyl alcohol much greater than at present. Rather than close down the plants and charge off their cost, it would be desirable to have new uses for alcohol waiting to absorb its production. Looking toward that day, it seems logical to push research now in any direction that promises an economic market for alcohol. That market may be in the modification of engine fuels. It is a challenge to chemurgy.

WALTER B. JONES

Business Must Be *Better* than Usual

YOU can't borrow billions from bankrupts. Paupers pay no taxes. If this avowedly costly war is to be paid for, the buyers of bonds and the payers of taxes must be allowed to get hold of money — a lot of money.

And if, as predicted in high places, it is to be a long war, it must be financed more from current taxes and less from borrowings. We dare not blow the bond bubble until it bursts. Moreover, if they are right who describe bank borrowings as the paper pyramid whence cometh unlimited inflation, we had better borrow from private parties — and see that they have it to lend. National income must go up, not down.

High national income based on high prices and high wages is of itself inflation, nothing more. It multiplies the cost of war, speeds a nation toward collapse of its currency and the revolution which follows like thunderclap after lightning bolt.

High national income based on increased production at stable prices and wages is true wealth. Without peril to our economy or to our government it strengthens the sinews of war and lifts the standards of living. It meets the needs of the military without undue sacrifice by civilian. It softens, if it cannot prevent, the shocks of post-war adjustment.

In war, as in peace, the philosophy of scarcity is fallacy. The right answer always is to produce, not to do without. The profession which promotes production is engineering. While the politician subtracts and the demagogue divides, the engineer multiplies. Now, as never before, America needs more engineers, more engineering, more heed of its principles.—W. B. J.

War Duties for Ag Engineers

AN indication of the greatly increased demand upon agricultural engineers incident to the all-out war effort in which our country is now vigorously engaged, is contained in the following note received by the secretary of the A.S.A.E. from H. B. Walker, head of the agricultural engineering department, University of California:

"Our agricultural engineering staff is exceptionally busy with war duties. We have organized and are now carrying out over 200 farm machinery repair clinics. We have a bulk-handling job (grain) this year since our bag supply is needed by the army. We are also trying to reclaim bale ties to save metal. Dehydration is at the top in processing for both fruit and vegetables. Our machinery work is bearing fruit also. Perhaps our nearness to war operations increases our usefulness, but certainly agricultural engineering is needed here more than ever, and I assume the same conditions exist all over the country."

Another instance of new responsibilities that agricultural engineers are being asked to assume as a result of the war, is contained in a statement by V. S. Peterson, extension agricultural engineer of Pennsylvania State College:

"The big task . . . today is the dissemination of information on reconditioning of machinery to farmers and to men doing farm machinery service work. During the past two weeks we have received requests for over 500 meetings and demonstrations to be held before March 15th, and before the close of the crop production season the number will probably reach close to 1,000.

"Attendance at these meetings and demonstrations held during the past few weeks has averaged over fifty. Thus we will be reaching between 25 and 50 thousand farmers."

If we take Pennsylvania as an average state, and if we assume that 39 other states are doing the same thing, it means that somewhere between one million and two million farmers will be getting, during this coming season, special instruction and advice from agricultural engineers of the state agricultural extension services.

The Challenge

IN HIS first communication to the section members, J. H. Nicholson, newly elected chairman of the Tennessee State Section of A.S.A.E., commenting on the outlook for agricultural engineers for the year 1942, sums up the situation concisely and effectively as follows:

"To some of us it will mean taking up arms in the service of our country; to others the postponement of cherished projects; to all of us the sidetracking of our personal aims and ambitions for the BIG JOB, the successful prosecution of the war for the preservation of our national security.

"Upon agriculture rests the responsibility for increasing the production of food, clothing, and other sinews of war to meet the pressing needs of the military forces and civilian populations of our own country and of our allies. To meet this responsibility in the face of increasing shortages in men, machines, and materials it will require all of the ingenuity, mechanical skill, and organizational ability we as a nation are able to muster.

"Upon the shoulders of agricultural engineers rests much of the responsibility for implementing this gigantic effort. It represents the greatest opportunity in the history of our profession. It is a challenge we *must* meet."

AGRICULTURAL ENGINEERING

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Conserving Soil and Water with Stubble Mulch

By Dr. H. H. Bennett

ABOUT eight years ago the program of the Soil Conservation Service got under way. From the beginning one cardinal principle dominated and guided its activities. Some called that principle idealistic and impracticable; others failed to grasp its significance.

That basic guiding principle was this: Adequate control of soil erosion on a farm, on a ranch, watershed, or any other land unit, requires the use and treatment of all the various kinds of land comprising that unit *in accordance with their individual needs and adaptabilities.*

Like any concise statement of a rule, this principle requires some qualification. First, the use and treatment accorded a parcel of land must be determined not only by its physical characteristics, but also by the available implements and methods of control and by the resources and preferences of the farmer himself. In other words, the treatment must fit not only the needs and adaptabilities of the *land* but the needs and adaptabilities of the *farmer* as well.

The second qualification of this general principle is that each distinct parcel of land to be treated must be considered in its relation to the next adjacent tract or to the entire unit area, the farm, the ranch, the watershed. The use and treatment of one area should, wherever possible, provide protection for adjacent areas. The management of lands on higher elevations should be determined in relation to downstream lands. Outlets for surface run-off should be located with proper consideration of adjoining lands. And, of course, the areas devoted to crops, grazing, and forest must fall within the pattern of a sound economic setup, or as near that as may be practicable.

The Soil Conservation Service has never deviated from this original concept. It has proved a practical and effective approach to the problem, and results generally have surpassed expectations.

To carry out a completely coordinated soil and water conservation program of this kind on a nation-wide basis requires the accumulation of a great deal of information for the blueprinting and planning of each farm and for execution of the job on the land. There are hundreds of different soils occupying varied slopes. These numerous varieties of land, occurring under a wide range of climatic conditions, are adapted to varied crops and cropping practices. From place to place, these differing conditions and uses result in varying susceptibilities to erosion.

It is almost safe to say that no two parcels of land are identical. Accordingly, each field — even each part of a field, pasture, or woodlot — requires its own particular set of conservation measures.

The conservationist has a choice of many different types of control measures for handling different types of problems. Unfortunately, effective conservation practices have not been developed for all the numerous problems and combinations of problems relating to the contrasting agricultural lands and practices of the nation. It is necessary, therefore, to seek constantly for cheaper, sounder, and more efficient ways of conserving our soil and water resources.

Soil conservation is probably the youngest of all the agricultural sciences. And so, from the very start, the work has been supported by a program of research through which new tools and methods of control and prevention are sought, and through which improvements on present techniques may be found. Soil conservation research has proved its value every step of the way.

In summarizing the progress of conservation to date, however, it seems to those of us who have been in intimate contact with the program all along, that the necessary average level of effectiveness, or efficiency, in the control and prevention work has not yet been attained. In some localities, results indicate that all that needs to be done has been accomplished. But for the country as a whole the work has been roughly rated by staff members of the ten regions of the Soil Conservation Service as ranging between 70 and 83 per cent effective in conserving soil and water.

Where good covers of dense vegetation and good stands of forest have been established, as on steep erodible land retired from cultivation, there seems to be no need for further protection. And where vegetative and mechanical conservation measures have been thoroughly joined and applied as part of a complete conservation treatment for the land, the results have averaged approximately 90 per cent in effectiveness

Paper presented December 3, 1941, at the fall meeting of the American Society of Agricultural Engineers at Chicago. Author: Chief, Soil Conservation Service, U. S. Department of Agriculture.

and often have approached pretty close to 100 per cent.

If present average effectiveness of conservation work lies somewhere between 70 and 83 per cent, then it is probable that in some localities the degree of success has hardly passed the halfway mark. That, of course, is not satisfactory, and, even though the situation may improve considerably as the various measures, such as crop rotations, have made their full contribution, higher levels of accomplishment must continue to be sought.

But more and more is being learned about control of erosion, conservation of rainfall, and better utilization of badly eroded land. A number of long strides forward have been made in this direction recently and other possibilities seem close at hand.

For example, the perennial lespedezas and kudzu have wrought profound changes in the use of much severely eroded land in many parts of the southern states. Lands which a little while ago were considered too poor or too steep to farm — even some areas that were so gullied they could not be plowed at all — are now producing excellent hay or grazing with these valuable crops. They are holding the soil, retarding run-off, reducing the effects of silting, and raising farm income. Many farms in the South are finally making headway toward diversification of crops and the raising of livestock as the result of the efforts towards soil conservation.

STUBBLE-MULCH METHOD EXPECTED TO INCREASE EFFICIENCY OF EROSION CONTROL PRACTICES

Just recently highly promising new methods and adaptations of older practices have been developed in certain localities for reducing losses of soil and rainfall by imitating Nature's way of keeping the ground clothed with a protective cover of vegetation or vegetative litter. Such surface material retards the scouring effect of both wind and water, prevents raindrops from striking the bare ground, and reduces evaporation.

This system or technique of utilizing the powerful protective effect of vegetative litter for controlling erosion, conserving rainfall, and reducing evaporation has been called the stubble-mulch method. It is expected to increase the efficiency of erosion-control practices over a large part of the country.

"Stubble mulch" is a technical term employed by conservationists to define that process of protecting cultivated or bare land in such a way as to conserve soil and soil moisture and reduce evaporation through the use of a complete or partial surface covering composed of some form of crop stubble or residue. The mulching material may consist of (1) that portion of the stubble of a preceding crop, as wheat straw or corn stalks, left standing on the ground, or partially incorporated with the soil; (2) that portion of the stubble or litter left lying on the ground after such operations as threshing or combining; or (3) such material as hay, straw, or other plant residues hauled in and spread over the ground. The method involves special tillage operations that do not turn the soil over. These usually fall under two main types, namely, subsurface tillage and stirring without inversion.

The primary function of stubble mulch, as already indicated, is to protect the surface from erosion by putting obstacles in the path of wind or water and to conserve moisture by favoring infiltration and reducing surface evaporation.

It is possible that various names may be needed to designate certain more or less distinctive phases of the stubble-mulch process, such, for example, as "straw mulch" (as wheat straw hauled in) and "standing mulch" (as soybean stubble left standing in fields as long as possible).

The stubble-mulch system of farming is the most promising conservation development in recent years. It has cut down erosion and run-off even more effectively than basin listing, which some conservationists have looked upon as the best way of holding soil and rainfall on the land, particularly in low rainfall areas. Basin listing *is* an excellent device for conservation of soil and water, especially where summer fallow is practiced or the land is left bare for any considerable period. Nevertheless the stubble-mulch system has demonstrated certain advantages over this method as well as over all other protective methods, except the permanent maintenance of dense cover of vegetation. Experience thus far indicates that the system provides a means of erosion control and water conservation which, alone or in combination with other measures, will prove 98 to 99 per cent effective or better, at least in some localities.

STUBBLE MULCHING IS A REVOLUTIONARY FARM PRACTICE AS ALL VEGETATION IS NOT PLOWED UNDER

The stubble-mulch system is a revolutionary farm practice in that it denies the customary method of plowing under all vegetation in preparing land for the next crop. Such practice exposes the unstable, freshly turned subsurface material to the chiseling effects of wind and rain. When rain strikes uncovered soil it becomes muddy water. When muddy water enters the small apertures of the soil, the suspended material filters out and seals or chokes the openings, so that more of the rainfall runs off the surface of the land rather than down into the soil. And more run-off usually means more soil erosion.

The stubble-mulching system is based on merely stirring the soil with plows that do not have moldboards to turn all the vegetation or vegetative litter under. It leaves a considerable part of the vegetable material — crop residue or vegetative litter — on the land as a surface protection against erosion. The practice has been extensively adopted in the wheat belt of the Pacific Northwest, where many farmers, instead of burning their wheat stubble, plow it so as to leave a substantial part on the surface to reduce the destructive impact of wind and water. Stubble mulching is being practiced on an increasing scale and with highly satisfactory results in parts of the Great Plains and to some extent in various other localities.

Farmers have been found who have practiced some form of stubble mulching for years. Agricultural scientists in various parts of the country and at various times have made some contribution to this practice. The Soil Conservation Service has examined these isolated experiences and tested various kinds of implements to be used with the practice as varied to fit different parts of the country. Farm machinery manufacturers, farmers, and soil conservationists have developed a number of subsurface tillage implements for the stubble-mulch operations employed in the Great Plains.

The powerful effect of a vegetative mulch in conserving soil and rainfall is strikingly illustrated by results obtained at the Statesville, N. C., soil and water conservation experiment station. Here, over a period of 3 years, one tract of land covered with a 2-in layer of undecomposed pine needles, and another tract covered with a layer of hardwood forest litter, lost as an average only 0.17 ton of soil per acre and 8.06 per cent of the total rainfall. However, a nearby area of the same soil and slope, cleared from original timber at the same time as the other two plots, but cultivated continuously to cotton, lost 32.26 tons of soil per acre and 16.13 per cent of the total rainfall during the same period. *(Continued on page 42)*

Machinery Requirements for Farming Through Crop Residues

By F. L. Duley and J. C. Russel

ABOUT four years ago the Office of Research of the Soil Conservation Service, in cooperation with the University of Nebraska, began studies on methods which it was hoped might lead to a more efficient use of rainfall and simultaneously reduce the disastrous effects of erosion.

These studies show that certain advantages in soil and moisture conservation can be gained through leaving crop-residue material on the surface of the soil, instead of plowing it under. These advantages are as follows:

1 An increase in capacity of soil to absorb water
2 Reduction of run-off
3 Reduction of water erosion and wind erosion
4 Reduction in rate of surface evaporation.

The ways in which residues on the surface aid in maintaining a high infiltration rate into the soil, the conditions under which they reduce evaporation, or the extent to which they prevent soil loss, conserve water, or increase crop yields as compared with conventional methods of farming, are subjects that have already been discussed in previous publications[1]. The particular objectives in this paper are to describe how farming has been done in our experiments, and to indicate how it can or should be done if residues are to be kept on the surface under practical field conditions. The emphasis here will be placed on implements and implement performance.

Agronomists, in carrying out their functions of soil and crop research, must use implements. In our case we employed the implements at hand and made changes, or sought other makes that could be modified more effectively. Implement companies through their executives and engineers have extended excellent and helpful cooperation. In turn, our activities have been open to their observation. As a result, there are now on the market a number of implements or attachments that can be used for thoroughly tilling the soil without burial of the residue. The working of soil beneath residues has been designated by us as "subsurface tillage", and the implements with which such work is done have been called "subsurface tillers".

Eventually there must be produced other implements, or attachments, for planting and tending crops through residues on the surface. Possibly also there should be some modifications in the machinery for harvesting crops so that residues can be returned to the land to the best advantage. All of these new developments are the province of the farm machinery engineers.

Subsurface Tillers. The agronomic requirements for tillage beneath residues are that the soil shall be well tilled but not necessarily inverted, and practically all residue, or as much of it as possible, shall be left on the surface. A subsurface tillage machine should operate through heavy residue or weeds without undue clogging. Only a minimum amount of the surface should be disturbed or trenched by the standards or shanks of the machine. So far, an implement to do all of these things with complete satisfaction has not been perfected. However, there are now available several machines that approach these requirements sufficiently that careful farmers can do an acceptable job of subsurface tillage after they have learned the principles of correct operation. This latter point is of vital importance in practically all of the machines.

The various subtillage machines that are now available may be classified into three groups, with respect to the type of cutting equipment used, as follows: (1) V-shaped sweeps, (2) straight blades, and (3) attachments for rod weeders.

Subsurface Tillers with V-shaped Sweeps. Figs. 1 to 4 illustrate some of the variations of the first type. The widths of most of the sweeps now in use vary from 22 to 45 in, although some wider ones have been used. The angle of the "V" usually varies from 60 to about 90 deg.

In the operation of V-sweep tillers, the sweeps are run perfectly flat. Penetration is obtained through the suction of the point and the pitch of the blade, and to a certain extent through the weight of the machine. The sweeps should be strongly built and have sufficient pitch to give the soil enough "throw" to pulverize it. The shanks to which the sweeps are attached should be strong, but not thick enough to cause furrowing of the soil.

This furrowing can be reduced further by the use of rolling coulters. As the coulter slits the soil, the V nose of the sweep spreads this kerf, allowing the shank room to pass through, and then the opening closes. However, if the shanks are too thick to clear the kerf, they catch trash and soil and thus make trenches.

The notable advantages of V-shaped sweeps is the ease with which they cut through and shed roots without becoming fouled, and their adaptability to operation at comparatively shallow depths. With sharp sweeps we have successfully subtilled through sweet clover and old stands of alfalfa.

Most of the V-sweep type tillers now available have been made through attachments to and modifications of already existing machines. The possibility of transforming existing equipment in such manner that it can be used for subsurface tillage should greatly simplify the change from our present system of plowing residues under to that of leaving these materials on the surface for protection.

Paper presented December 3, 1941, at the fall meeting of the American Society of Agricultural Engineers at Chicago. Published with the approval of the Chief of Research, Soil Conservation Service, U. S. Department of Agriculture, and the Director of the Nebraska Agricultural Experiment Station, Journal Series No. 302. Authors: Senior soil conservationist, Soil Conservation Service, U.S.D.A., and cooperative agent and professor of agronomy, University of Nebraska, respectively.

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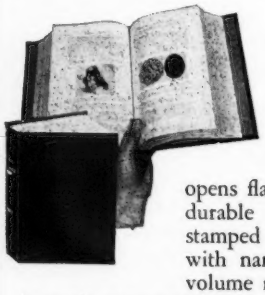

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STUDENT BRANCH NEWS

(Continued from page 30)

On Friday evening, December 12, the Branch gave a banquet in honor of Prof. U. H. Davenport. Prof. Davenport is the oldest faculty member in the agricultural engineering department of the University of Georgia. He is known to students as "Fess" Davenport, and many of his friends, nearer his own age call him "Davie". "Fess" has been an instructor in the agricultural engineering department ever since there was one. He teaches the more technical subjects, namely, mechanics, electrical engineering, etc., the ones that are hard and easy to flunk. But pass or flunk the students' love and respect for "Fess" Davenport never changes.

The banquet was held at the new Ag Hill dining hall. A three-course dinner was served, the main course being turkey with all the trimmings. The program consisted of C. B. Seckinger, master of ceremonies; Prof. U. H. Davenport, "Reminiscences of the University"; Cecil Mize, "Dedication and presentation of honor key"; W. D. Kenny, "Farewell to Mr. Shepherd", who leaves for army duty next quarter; Prof. R. H. Driftmier, "Welcome to Mr. Kinard", who is a new faculty member in the department. Much of the credit is given to Cecil and Clyde Mize for making this banquet a successful one.

At the last meeting officers were elected for the winter quarter. They are as follows: Clyde Mize, president; Harold King, vice-president; W. A. Strauss, secretary; Cecil Mize, scribe.

EMPLOYMENT BULLETIN

The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted," or apply for positions under "Positions Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted." Any notice in this bulletin will be inserted once and will thereafter be discontinued, unless additional insertions are requested. There is no charge for notices published in this bulletin. Requests for insertions should be addressed to ASAE, St. Joseph, Michigan.

POSITIONS OPEN

AGRICULTURAL ENGINEER wanted for farm structures research work in the agricultural experiment station of a southeastern college. Only a man with some research experience and not subject to immediate military service will be considered. Work will be primarily concerned with storage buildings. Good fundamental training with good scholastic records necessary. Salary up to $2,700 according to qualifications. PO-134

POSITIONS WANTED

AGRICULTURAL ENGINEER, also farm and supply manager, has had 20 years' experience in agricultural pursuits as manager of large farming enterprise and agricultural supply house, and as chief agricultural engineer of large irrigation development in the West. Has had technical training and practical experience in all phases of engineering and agricultural production, development, and marketing. Best of references. Forty-four years of age. Married. PW-341

AGRICULTURAL ENGINEER with 15 years' experience in the farm equipment industry; knows both farmer and tractor and implement industry in all sections of world; especially Canada and U.S.; advertising, public relations, editorial, camera, radio; can direct a complete service for dealers and factory; knows governmental and agricultural college officials; Farm Bureau; boys' and girls' clubs, livestock and special crop associations. Will locate anywhere the right firm or industry may wish. Have production records that speak. Personal portfolio mailed on request. PW-343

AGRICULTURAL ENGINEER desires employment offering larger opportunity. Ten years' experience in the electric utility industry and two years' experience as an assistant extension agricultural engineer. Good farm background. Particularly qualified to handle all phases of rural electrification, pump irrigation, and farm machinery. Capable of planning and conducting educational or promotional activities. Holds a state professional engineering certificate. Thirty-six years of age. Married. References on request. PW-344

AGRICULTURAL ENGINEER with B.S. degree from midwestern college (1938) and M.S. degree from southern college (1940), desires employment with the Soil Conservation Service, in a defense industry, or in other engineering work. Has 1½ years' experience as engineer with the U. S. Soil Conservation Service in the South and in the Pacific Northwest. Familiar with agriculture in most parts of the United States. Civil Service rating as junior engineer. Eligible for reappointment. Age 35. Married. PW-345